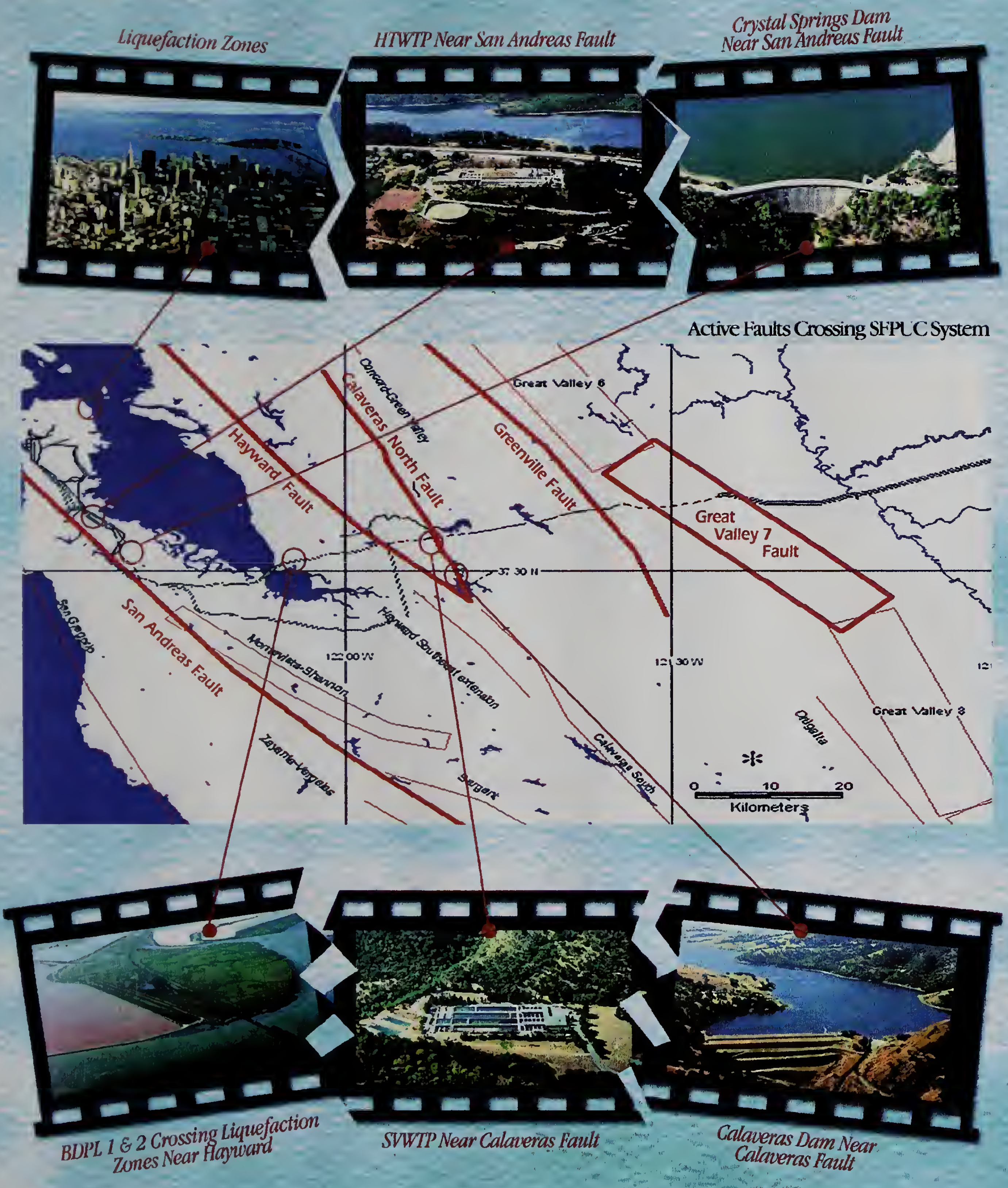


SFPUC Facilities Reliability Program

Phase II - Regional System Overview

January 2000

The Water Reliability Partnership

SAN FRANCISCO PUBLIC LIBRARY
3 1223 05611 3153

San Francisco Public Utilities Commission

FACILITIES RELIABILITY PROGRAM
PHASE II: REGIONAL SYSTEM OVERVIEW

Phase II Final Report

January 2000

DOCUMENTS DEPT.

JAN 2 4 2000

SAN FRANCISCO
PUBLIC LIBRARY

Prepared by

THE WATER RELIABILITY PARTNERSHIP
CH2M HILL, Inc.
Olivia Chen Consultants, Inc.
Montgomery Watson
EQE International

FACILITIES RELIABILITY PROGRAM
PHASE II: REGIONAL SYSTEM OVERVIEW

Phase II Final Report
Table of Contents

Technical Memorandum No. 1: Hazard Events and Maps

Technical Memorandum No. 2: Baseline Reliability Assumptions

Technical Memorandum No. 3: Baseline Reliability Response
- Appendix A: Facility Linkages and Functional/Operational Relationships

Technical Memorandum No. 4: Phase III Work Plan and Other Recommendations
- Appendix A: Early Implementation Activities - Scopes of Work
- Appendix B: Critical Facility Data Sheets
- Appendix C: Example Scope of Work to Determine Customer Service Demands
- Appendix D: Framework for Communications

3 1223 05611 3153

Digitized by the Internet Archive
in 2014

https://archive.org/details/facilitiesreliab2000wate

SFPUC Facilities Reliability Program Phase II – Regional System Overview

SUBJECT:	Technical Memorandum No. 1 **Hazard Events and Maps**
PREPARED BY:	The Water Reliability Partnership
Principal authors:	EQE International
DATE:	April 27, 1999

Table of Contents

Page

1.0 INTRODUCTION AND PURPOSE
- 1.1 Overview 1
- 1.2 Purpose and Outline of TM No. 1 1

2.0 DESCRIPTION OF HAZARD EVENTS
- 2.1 Approach to Identifying Hazard Events 1
- 2.2 Earthquake Scenarios 2
  - 2.2.1 Magnitude and Intensity 3
  - 2.2.2 Faults and Hazard Events 3
  - 2.2.3 Earthquake Effects 7
    - 2.2.3.1 Ground Shaking 7
    - 2.2.3.2 Fault Rupture 7
    - 2.2.3.3 Liquefaction Potential and Lateral Speading 9
- 2.3 Landslide 10
- 2.4 Flood Scenarios 10
- 2.5 Fire Scenarios 10
- 2.6 Wear and Tear 11
- 2.7 Summary 11

3.0 DEVELOPMENT OF HAZARD MAPS
- 3.1 Approach to Mapping 12
- 3.2 Earthquake Map 17
  - 3.2.1 Alquist-Priolo Fault Zones 17
  - 3.2.2 Active Faults According to the California Department of Mines and Geology 19
  - 3.2.3 Liquefaction Susceptibility 21
  - 3.2.4 Probabilistic Map 23
  - 3.2.5 Earthquake Scenarios 25
- 3.3 Flood Map 31
- 3.4 Fire Hazard Maps 36
- 3.5 Landslide, and Wear and Tear 40

Figures

Page

Figure 2.1 Active Earthquake Faults, San Francisco Bay Area 5
Figure 3.1 SFPUC Water Distribution System 13
Figure 3.2 View of the SFPUC System in the City of San Francisco 14
Figure 3.3 View of the SFPUC System From San Francisco to Sunol Filtration Plant 15
Figure 3.4 View of the SFPUC System From Sunol Filtration Plant to Hecht Hetchy Reservoir 16
Figure 3.5 Map of the Alquist-Priolo Faults and the SFPUC System (as of 1994) 18
Figure 3.6 Map of Active Faults Crossing the SFPUC System 20
Figure 3.7 Map of Liquefaction Susceptibility in the Bay Area 22
Figure 3.8 Probabilistic Ground Shaking Hazard Map 24
Figure 3.9 Peak Ground Accelerations from a San Andreas M_w 7.9 event 26
Figure 3.10 Peak Ground Accelerations from a Calaveras M_w 6.8 event 27
Figure 3.11 Peak Ground Accelerations from a Great Valley M_w 6.7 event 28
Figure 3.12 Peak Ground Accelerations from a Hayward M_w 7.1 event 29
Figure 3.13 Peak Ground Accelerations from a Greenville M_w 6.9 event 30
Figure 3.14 Flood Hazard Map and the SFPUC System 32
Figure 3.15 Flood Hazard Map and the SFPUC System – San Francisco and San Mateo Counties 33
Figure 3.16 Flood Hazard Map and the SFPUC system – South Bay and Sunol Valley 34
Figure 3.17 Flood Hazard Map and the SFPUC System – Sierras 35
Figure 3.18 Wildland Fire Hazard Map and the SFPUC System 37
Figure 3.19 Urban Conflagration and Fire Following an Earthquake Potential and the SFPUC System 39
Figure 3.20 Map Showing Landslide Areas in the San Francisco Bay Area 41
Figure 3.21 SFPUC Facilities Vulnerable to Wear and Tear 42

Figures (Cont.)

Page

Figure 3.22 SFPUC Facilities Vulnerable to Wear and Tear – View of the Peninsula 43

Figure 3.23 SFPUC Facilities Vulnerable to Wear and Tear – View of Sunol Valley 44

Figure 3.24 SFPUC Facilities Vulnerable to Wear and Tear – View of the Sierras 45

1.0 INTRODUCTION AND PURPOSE

1.1 Overview

The SFPUC Facilities Reliability Program has been divided into four phases:

Phase I:	Facilities Assessment
Phase II:	Regional System Overview
Phase III:	Risk Assessment and Development of Alternatives, and
Phase IV:	Environmental Review and Plan Implementation

The Water Reliability Partnership (which is a joint venture of CH2M-Hill, EQE International, Montgomery Watson, and Olivia Chen Consultants) has been retained to conduct Phase II of the program.

1.2 Purpose and Outline of TM No. 1

TM No. 1 is a part of the Phase II Task 2 work. The overall goal of Task 2 is to review and refine the completed Phase I work, and TM No. 1 supports this goal with regard to Hazard Events, by providing:

- in Section 2: descriptions of hazard events
- in Section 3: hazard maps

2.0 DESCRIPTION OF HAZARD EVENTS

This section presents descriptions of selected hazard events which can be employed in scenario-based analyses of SFPUC Facilities.

2.1 Approach to identifying hazard events

In Phase 1, SFPUC personnel assessed facilities in a general way for several hazards (earthquake, fire, flood, landslide, age, vandalism or sabotage, wear and tear, and power outage). However, in that work, hazards were defined only generally (e.g., a high earthquake rating is defined as *near a known fault or older than 15 years;* high flood rating is *subject to inundation in 10 year storm*)1. The Phase 1 study collected information about the exposure of SFPUC facilities to various hazards, but did not use the information to determine facility criticality or rank order of importance. The project team postponed the assessment of facility risk of failure from known hazards for later analysis, when the risks could be predicted, assessed and quantified with greater technical precision. Furthermore, *the Phase 1 study assessed the criticality of each facility to the overall system if it failed individually...[and]...did not assess...if all other redundant facilities failed simultaneously, or in combinations, during the same event*[2].

---

[1] Phase 1, Final Report, Nov. 1995. Attach. C.

[2] Phase 1, Final Report, Nov. 1995. , p. 13.

This section presents results of a limited review of regional hazards (earthquake, flood, fire, power outage, landslide, age, and wear and tear) conducted to identify selected hazard events which can be employed in scenario-based analyses of SFPUC Facilities. The purpose is not to develop detailed and highly rigorous characterizations of earthquake or other hazard effects at individual facilities, but rather to develop (on the basis of a limited effort) hazard events which may affect one or more major SFPUC facilities.

In determining hazard events, the likelihood or probability of occurrence of the event is a defining factor - that is, whether one selects as a hazard event a frequent event (e.g., an event such as a flood with 10% per annum probability of exceedance, hereinafter sometimes referred to as a 'ten year' event) or a rare event (e.g., a 'thousand year' event) determines the severity of effects to be designed or mitigated against. No specific or consistent criteria have been specified by SFPUC for this purpose - indeed, one of the purposes of the present project is to use this project's findings to develop criteria for a more consistent 'uniform hazard' event definition, for use in future phases. In the absence of specific criteria, hazard mapping and hazard event identification has been made based on the general basis of current practice, building code requirements, an early consideration of potential consequences of each hazard event, and available information. This has resulted in, for earthquakes, '500 year' or greater hazard events; for floods, '100 year' hazard events, etc. While inconsistencies may appear to exist, we believe these events are appropriate for this project's and the SFPUC's current purposes.

These hazard events are intended to be combined with a characterization of the water and power systems to determine, in an approximate manner, which facilities are either most vulnerable and/or critical to system performance. The results of that determination are intended to form the basis for development of a Phase III work scope. In Phase III detailed and rigorous characterizations of earthquake or other hazard effects may be developed for individual facilities, as appropriate. It should be noted that the process just outlined constitutes a limited and non-rigorous systems analysis of sorts - a rigorous systems analysis would require probabilistic analyses and techniques which are beyond the present scope of work.

In summary, hazard events on a deterministic scenario basis have been identified based on a limited review of the available literature and professional judgement, for purposes of an approximate system-wide analysis intended to form the basis for development of a Phase III work scope.

2.2 Earthquake scenarios

SFPUC Facilities cross or are located near a number of earthquake faults with the potential for large magnitude events capable of causing strong ground shaking and potential damage. The following sections provide summary information on the definitions and measures of earthquake magnitude and intensity, and the known faults believed capable of generating earthquakes that could affect SFPUC Facilities. For each fault, we define a maximum magnitude, which constitutes the associated hazard event. We then summarize associated effects, in the event such earthquakes occur. Section 3 presents maps for strong ground shaking, fault rupture potential locations, liquefaction and landsliding.

2.2.1 *Magnitude and Intensity*

Earthquake magnitude and the magnitude scale are a well known but typically misunderstood means of describing the energy released during an earthquake. The most commonly used scale is the one developed by Richter[3]. More recently, **seismic moment** has been employed to define a **moment magnitude** M_W (Hanks and Kanamori, 1979[4]), which is increasingly becoming the standard measure of earthquake magnitude (and which will be used herein unless otherwise noted). Magnitude scales are intended to be objective, instrumentally determined ratings of the size of an earthquake. There are no fixed maximums or minimums to scales. The smallest felt earthquake has a magnitude of about 2.0, while 9.5 (Chile, 1960) is the largest magnitude ever recorded. An increment in magnitude of 1.0 represents an increase of approximately 32 times the amount of energy released.

While magnitude describes the size of an earthquake, **intensity** describes the effects of shaking in terms of damage at a particular location. Intensity is governed by the magnitude of an earthquake, the distance from the site to the fault rupture, and local geologic conditions. A small or moderate earthquake may generate strong ground shaking, but the areal extent of this shaking will be substantially less than that generated by a major earthquake. The Modified Mercalli Intensity (MMI) Scale is commonly used to measure intensity, and is composed of 12 categories of ground motion intensity, from I (not felt, except by a few people) to XII (total damage). The MMI Scale is somewhat subjective; it is dependent on personal interpretations and, to some extent, quality of construction in the affected area.

Objective instrumental measures commonly employed to measure strong ground motion at a site include **peak ground acceleration** (PGA), peak ground velocity (PGV), and response spectral acceleration, velocity and displacement (S_a, S_v, S_d, respectively). For more information on magnitude, intensity and related matters, see Bolt[5], or Scawthorn[6]. In this project, peak ground acceleration is the only measure of earthquake intensity considered, and it is commonly shown as a percentage of the acceleration of gravity.

2.2.2 *Faults and Hazard Events*

This section discusses active earthquake faults and hazard events potentially affecting SFPUC Facilities. Figure 2-1 shows a number of these faults in the vicinity of the San Francisco Bay Area, while Section 3 of this Technical Memo shows these faults in greater detail, and relative to SFPUC Facility locations. Because a wide variety of technical literature discusses earthquake faults and their potential activity, with substantial variance of opinion between authors, most of the data and material presented herein is drawn from a recent standard reference developed as part of the Uniform Building Code[7] (hereinafter referred to as CDMG, 1998).

---

[3] Richter, C. F (1935) An instrumental earthquake scale, *Bulletin* of the Seismological Society of America, V 25, p 1-32.

[4] Hanks, T.C. and Kanamori, H. (1979) A moment magnitude scale, *J. Geophys. Res.*, v. 84, pp. 2348-2350.

[5] Bolt, B.A. *Earthquakes*, W.H. Freeman and Co., New York, 1993.

[6] Scawthorn, C. *Earthquake Engineering*. 1997. Chapter in *Handbook of Structural Engineering*, W.F. Chen, editor. CRC Press, Boca Raton FL.

An active fault is defined as one for which either there is a historical record of earthquake activity or evidence that movement has occurred within the last 11,000 years. Future movement on these faults is considered probable. The faults that will most likely affect SFPUC Facilities, and we recommend for Hazard Events, are briefly described below.

The San Andreas Fault: The San Andreas fault system is a major feature of California tectonics and is responsible for most of California's largest earthquakes. The northern portion of the San Andreas fault extends for more than 310 miles north from San Juan Bautista. The earliest recorded earthquake on the San Andreas fault occurred in October 1800 near San Juan Bautista. In 1838, an earthquake located on the peninsula south of San Francisco had an estimated magnitude in excess of 7.0. Accounts of this earthquake describe a large fissure extending from San Francisco to an area near San Jose. The San Francisco earthquake of April 18, 1906, had an estimated magnitude of 8.3 (moment magnitude 7.8) and generated strong vibratory ground motions that caused damage throughout Northern and Central California, including significant damage to water mains and facilities on the Peninsular and in San Francisco. Note that the San Andreas fault forms a rift valley in which Upper and Lower Crystal Springs reservoirs are placed, and that the fault intersects an abutment of San Andreas reservoir (both Lower Crystal Springs and San Andreas dams existed in 1906 but neither were seriously damaged).

On October 17, 1989, the magnitude 6.9 Loma Prieta earthquake occurred on the San Andreas fault, east of Santa Cruz. In addition to severe damage in the historic central business districts of Los Gatos, Santa Cruz, and Watsonville, ground shaking resulted in moderate to severe structural damage throughout the Bay Area. Damaged structures included the San Francisco Bay Bridge, as well as several elevated freeways in Oakland and San Francisco. Soft-soil areas of San Francisco sustained very intense ground motion, the collapse of many buildings, and major damage to underground utilities including water mains. In various other locations (e.g., Oakland, Santa Clara), water utility facilities were damaged.
CDMG (1998) indicates a maximum magnitude of 7.9 for the 1906 segment of the San Andreas fault.

---

[7] California Dept. of Conservation, Division of Mines and Geology. 1998. *Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada, To be used with the 1997 Uniform Building Code.* Prepared in cooperation with the Structural Engineers Association of California, Seismology Committee. International Conference of Building Officials, Whittier.

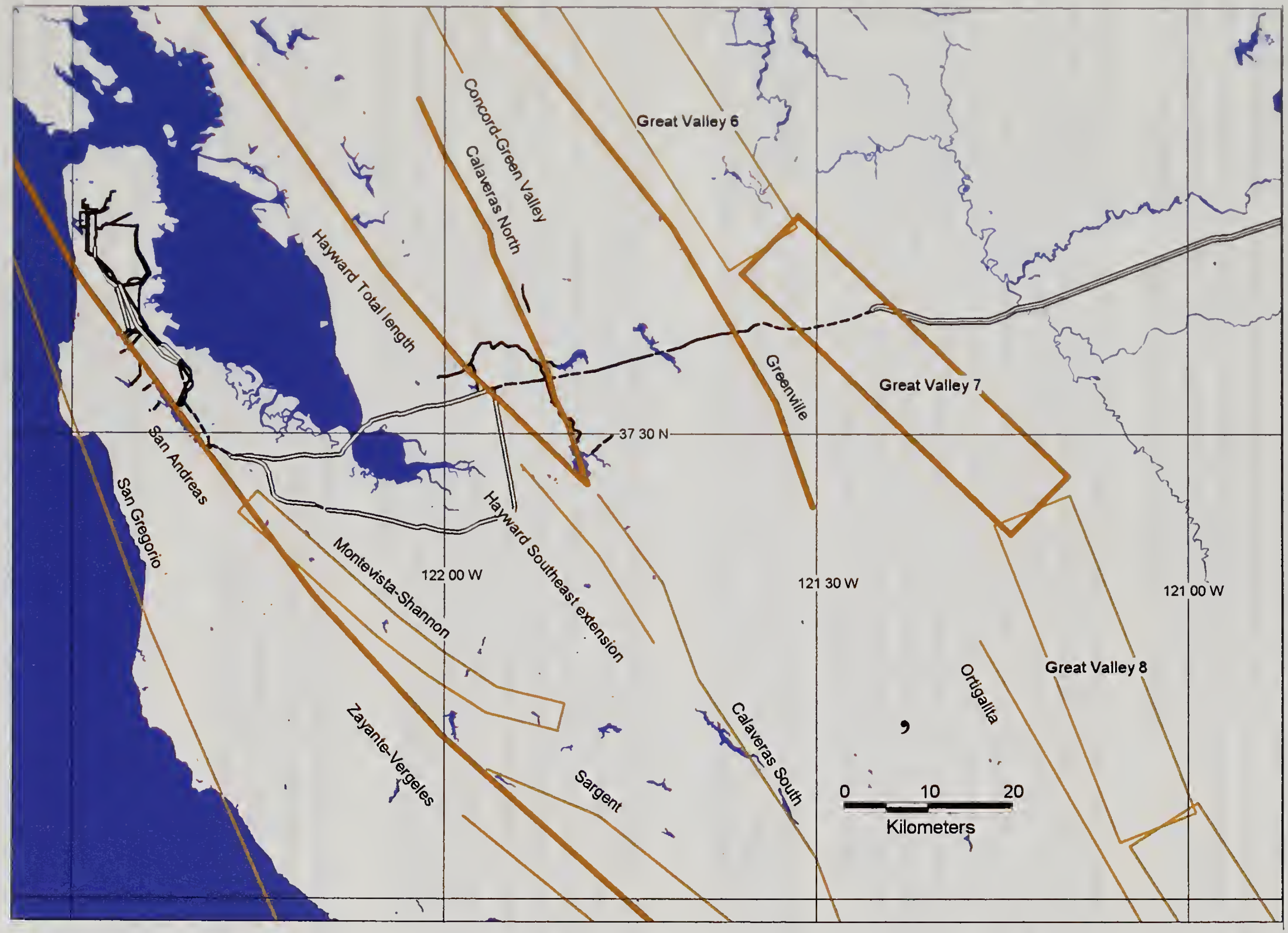


Figure 2-1: Active Earthquake Faults, San Francisco Bay Area

The Hayward Fault: The Hayward fault is located on the eastern side of the San Francisco Bay, extending northwesterly approximately 55 miles from San Jose to San Pablo. The Hayward fault is one of the major active branches of the San Andreas fault system in Northern California. In 1868, an earthquake with an estimated moment magnitude of 6.8 ruptured for 20 miles and severely damaged every building in the village of Hayward. More recent damaging earthquakes occurred in 1915, 1933, and 1937. The Hayward fault is believed capable of producing earthquakes of maximum moment magnitude 7.1 (CDMG, 1998).

The Calaveras Fault: The Calaveras fault system is a major branch of the San Andreas system in Northern California, splitting from the San Andreas a few miles south of Hollister and extending approximately 80 miles northeast to an area just north of Danville. From there, several branches continue northward. Historically, a number of earthquakes have occurred along the Calaveras fault. The strongest recorded tremor is the 1861 Amador Valley earthquake, which occurred near Dublin and produced a Modified Mercalli Intensity of VIII. The April 24, 1984, Morgan Hill earthquake had a moment magnitude of 6.2 and caused damage in Morgan Hill, Gilroy, and San Jose. It has been estimated that the Calaveras North fault is capable of producing a moment magnitude 6.8 earthquake (CDMG, 1998).

The Greenville Fault runs parallel but to the east of the Calaveras fault, due east of Walnut Creek, with end points at approximately (37.42 -121.50, 37.98 -121.94), for a length of about 73 km. The Greenville Fault is believed capable of generating a moment magnitude 6.9 earthquake.

The Great Valley Fault Zone: The Great Valley FZ is a 500-km-long, west-dipping, seismically active blind fold and thrust belt series that underlies the Coast Ranges–Central Valley geomorphic boundary. Earthquakes associated with this series of faults include the 1983 moment magnitude 6.5 Coalinga and the 1985 moment magnitude 6.1 Kettleman Hills events. The Great Valley FZ is also the probable source of the 1892 Winters earthquakes (moment magnitudes 6.6–7.0). Relative consistency of geomorphic expression and regional geologic relationships suggests that deformation rates are similar along the entire length of the system. It is estimated that segments of the Great Valley FZ near SFPUC facilities are capable of generating earthquakes with moment magnitudes up to 6.7.

For this study we used the faults and fault parameters defined by the California Division of Mines and Geology (CDMG, 1998) in their probabilistic seismic hazard assessment for the state of California. These faults differ from Jennings 1995[8] map compilation of fault activity for California. Jennings included faults that are over 1.6 million years old while CDMG used faults that are generally younger than 100,000 years.

Figure 2-1 shows a number of other faults in the Bay Area (e.g., San Gregorio, Montevista-Shannon, etc). While these are significant faults, they do not intersect SFPUC pipelines, and shaking they may generate at SFPUC facilities will in all cases generally be less than the hazard events identified above. On this basis, we have not defined them as hazard events. Table 2-1 summarizes the defined earthquake hazard events for this project.

---

[8] Jennings, C. (1995). New fault map of California and adjacent areas. *California Geology*, Vol. 48, No. 2, pages 31-42.

Southern Foothills Fault Zone: The southern Foothills Fault Zone (SFFZ) forms the structural geologic boundary between the Sierra Nevada and the San Joaquin Valley in the vicinity of the Hetch Hetchy aqueduct crossing. The Melones and Bear Mountains fault zones are primary faults within this distributed zone of fault strands that is over 25 kilometers wide. Slip-rates and activity level of faults within the SFFZ are poorly constrained, but are recognized as being quite low (Petersen and others, 1996[9]). Poorly constrained composite slip rate across the Bear Mountains and Melones fault zones have been estimated at 0.05 millimeters per year over very short segments of the faults (Woodward-Clyde Consultants, 1978[10]; PG&E, 1994[11]). This rate of estimated slip (and implied level of earthquake activity) is four orders of magnitude lower than that of the San Andreas fault and three orders of magnitude lower than the Hayward fault in the San Francisco Bay area. In CDMG's latest seismic hazard assessment for the State of California (Petersen and others, 1996), the entire Foothills Fault Zone was modeled as an area source having a maximum magnitude earthquake of 6.5. Because of the very low activity rate and low maximum magnitude of the fault zone, there was insufficient reason to treat faults within the zone on an individual basis. It is not shown as an Active fault, for purposes of determination of near-source factor, in CDMG 1998, and is not designated as a Special Studies Zone. Based on its very low activity relative to major faults in the San Francisco Bay Area, its non-inclusion in CDMG 1998, non-designation as a Special Studies Zone, and CDMG decision not to treat faults within the zone on an individual basis, we have not included the SFFZ as a Hazard Event.

TABLE 2-1
EARTHQUAKE HAZARD EVENTS

Fault	M_w
San Andreas	7.9
Calaveras North	6.8
Great Valley Fault	6.7
Hayward	7.1
Greenville	6.9

---

[9] Petersen, M.D., W.A. Bryant, C.H. Cramer, T.Cao, M.S. Reichle, A.D. Frankel, J.J. Lienkaemper, P.A. McCrory and D.P. Schwartz (1996). "Probabilistic Seismic Hazard Assessment for the State of California", California Department of Mines and Geology Open-File Report 96-08, 59 p.

[10] Woodward-Clyde Consultants (1978). "Stanislaus Nuclear Project Site Suitability: Site Safety Report for PG&E: Foothills Fault Study", v. 4, Appendices C.1 and C.2, v. 6, Appendices C.4 and C.4A.

[11] Pacific Gas and Electric Co. (PG&E) (1994). "Characterization of Potential Earthquake Sources for Rock Creek (Drum) Dam", Report for FERC 2310, Drum Spaulding Project State Dam No. 97-43, 89 p

2.2.3 *Earthquake Effects*

2.2.3.1 Ground Shaking

For each hazard event, ground shaking can be determination at each location in the region. This determination should take into account local soil conditions. Maps in Section 3 present patterns of ground shaking (peak ground acceleration, PGA) for each earthquake hazard event, taking into account local soil conditions. Also provided are maps of '475 year' probabilistic shaking (ie, the PGA expected to occur at all locations, with a 10% probability of exceedance in 50 years, taking into account all seismic sources including random seismicity). The probabilistic shaking maps are included to account for lower level but still possible shaking at sites distant from the defined earthquake hazard events, such as in the Sierras.

2.2.3.2 Fault Rupture

Active earthquake faults by definition are associated with slip across the fault, either aseismically (ie, creep) or coseismically (ie, rupture). Figure 1 and Section 3 indicate locations where active earthquake faults cross or intersect SFPUC pipelines or other facilities. At each of these locations, the potential for large sudden coseismic fault rupture exists. In detail (ie, to within inches or a few feet), the reliable location of fault intersection with SFPUC facilities cannot be determined from maps, but must be determined by site-specific trenching and geologic investigation. For this reason, California requires geologic investigation within a zone around each active fault (these zones are termed Special Studies Zones, and are sometimes referred to as Alquist-Priolo zones; note that the Special Studies Zones depict fault traces, which are intended only as a guide). Until site-specific trenching and geologic investigation can be performed at SFPUC facilities, Special Studies Zone maps can provide guidance as to where a specific fault trace may occur. For certain faults, such as the Great Valley fault zone, fault traces may not appear at the surface.

The specific vector of fault displacement at each location depends on a number of factors including regional tectonics, earthquake moment magnitude and local site conditions, and can be estimated (with some associated uncertainty) for purposes of design and mitigation. Generally speaking, depending on the various factors, displacement will range from tens of centimeters to meters. Estimation of specific vectors is beyond the scope of the present project. Absent estimation of specific vectors, we recommend that the fault rupture hazard event be taken as a displacement of several meters.

For fault rupture hazard events, given the above and unless the SFPUC facilities at a specific fault crossing have been specially designed for fault displacements, we recommend that the SFPUC facility intersected by a fault be considered to have failed. This recommendation is based on:

- In most cases, fault rupture results in major damage if not catastrophic shearing, of pipes.
- For buildings and other structures, displacements may or may not result in catastrophic failure, depending on foundation type and other factors. This may

seem surprising, but fault ruptures of large displacement have been observed to come up to and go around a building. In fact, in the 1906 San Francisco earthquake, the fault intersected the east abutment of the San Andreas dam (and an associated tunnel) without significant degradation of the dam (the tunnel partially collapsed at the fault crossing and was otherwise relatively undamaged - a nearby trestle collapsed)[12]. Because shearing displacements of several meters are clearly significant, catastrophic failure cannot be ruled out without detailed investigation, leading to our recommendation above.

2.2.3.3 Liquefaction Potential and Lateral Speading

Liquefaction refers to a process resulting in a soil's loss of shear strength, due to a transient excess of pore water pressure. . The water, which had occupied the voids (and being incompressible), comes under increased pressure and migrates upward towards or to the surface, where the pressure is relieved. The water usually carries soil with it, and the resulting ejecta are variously termed **sand boils** or **mud volcanoes.** Soils most susceptible to liquefaction are those with high water tables and, typically, of a loose uniformly graded sandy composition[13].

Liquefaction has occurred in numerous earthquakes and been a significant agent of damage, including the 1906 San Francisco and 1989 M_w 7.1 Loma. In both events, major liquefaction and resulting damage occurred at various locations on the Peninsular and in San Francisco, causing building damage and numerous underground pipe failures[14].

Determination of liquefaction requires first identification of soils susceptible to liquefaction (ie, those with high water tables and of a more or less loose uniformly graded sandy composition), and then analysis of the soil for liquefaction. Analysis involves computation and/or laboratory work to develop a comparison of the cyclic shear strength of the soil versus the number of cycles at the anticipated shear stress, given the hazard event. Because cycles and shear stress vary with location, mapping of expected liquefaction is a data-intensive effort, beyond the scope of the present project.

Section 3 presents a map of liquefaction susceptibility - that is, a map showing the distribution of soils with a high water table and of a more or less loose uniformly graded sandy composition, that would be anticipated to liquefy should a large earthquake occur within the near to medium field. This map may be used in conjunction with the maps of ground shaking for each hazard event, to identify SFPUC facilities that may be subjected to significant liquefaction. If facilities are identified as on high liquefaction susceptibility soils, and are in the near to medium field of the hazard events, it is possible they will be subjected to liquefaction and/or associated effects (**lurching** or **lateral spreading**), and will therefore be candidates for detailed investigation.

---

[12] Lawson, A. C.; Reid, H.F. (1908-10) *The California Earthquake Of April 18, 1906. Report Of The State Earthquake Investigation Commission, California.* State Earthquake Investigation Commission, Carnegie Institution of Washington, Washington, D.C. [see esp. pgs. 92 *et seq.*).

[13] For more information on liquefaction, see Kramer, S.L., 1996, *Geotechnical Earthquake Engineering*, Prentice Hall, Englewood NH. or Kramer, S.L.. and Scawthorn, C., 1999 (to appear), *Geotechnical Earthquake Considerations*, chapter in Handbook of Bridge Engineering, W.F. Chen, editor. CRC Press, Boca Raton FL.

[14] O'Rourke, T.D. , Pease, J. W.; Stewart, H. E. (1992) Lifeline performance and ground deformation during the earthquake., in O'Rourke, Thomas, editor Geological Survey (U.S.) *Loma Prieta, California, Earthquake Of October 17, 1989: Marina District.* US Government Printing Office, Washington, DC.

2.3 Landslide

Landsliding can occur under a number of conditions, either singly or in combination, including gravity along (when weathering has degraded soil or rock strength), intense rainfall, undermining (either natural, such as due to erosion, or man-made) and/or earthquake. Factors affecting landsliding hazard include slope, soil type, water content, angle of bedding, and surcharge. Detailed investigation of landslide hazard is data-intensive and beyond the scope of the present project. Section 3 presents maps of Landslide Potential, based on regional information such as slope and soil type. These maps may be used either alone or in conjunction with the maps of ground shaking for each earthquake hazard event, to identify SFPUC facilities that may be subjected to landsliding. If facilities are identified as in high landsliding potential areas, it is possible they will be subjected to landsliding and will therefore be candidates for detailed investigation.

2.4 Flood scenarios

Section 3 presents maps of areas anticipated to sustain flooding with a probability of 0.01 per annum (ie, '100 year' floodplains), as determined by the Federal Insurance Administration, overlaid on SFPUC facilities. Each flood may be considered an individual hazard event. Correlation between individual floods may occur, and can be determined via statistical analysis of stream records, but such reduced data is not currently available. To approximately account for correlation, two or more adjacent or relatively nearby floodplains can be considered to flood simultaneously, and thus constitute one hazard event. Depending on the relative importance of possibly correlated flooding, further investigation of correlation may be appropriate in later phases.

2.5 Fire scenarios

Section 3 presents maps of areas anticipated to be subject to large fires, either of a wildland or an urban nature.

Wildland fire hazard was mapped based on available information on wildland fuels (type and amount) combined with slope conditions and assuming adverse moisture and wind conditions. Wildland fires pose a problem not only to individual SFPUC above ground facilities, but also to the several Peninsular and Hetch Hetchy watersheds, in that large fires can result in major turbidity incidents, affecting water quality. The mapping in Section 3 shows several large but distinct areas as having significant wildland fire hazard. For wildland fire hazard events, we recommend that any one of these mapped areas be considered as an occurring large wildland fire, but not simultaneous fires in more than one area.

Large urban fires include fires following earthquake, and non-earthquake large emergencies. That large non-earthquake fires can occur was seen in 1991 when the East Bay Hills fire destroyed approximately 3,800 units in a few hours, while the 1906 San Francisco earthquake and resulting fire (28,000 buildings destroyed) indicates the potential for fires following earthquake. Information for mapping purposes regarding large urban non-earthquake fire hazard is not available. Mapping of potential fires following earthquake has been performed for the insurance industry[15], which has been used for the maps in Section 3 to indicate general urban areas where conflagration potential is particularly high. For urban fire hazard events, we recommend

(a) For non-earthquake related fires: any one of these urban areas be considered as an occurring large urban fire, but not simultaneous fires in more than one area

(b) For large fires following earthquakes, all of the mapped urban areas be considered occurring simultaneously following a maximum earthquake on either the San Andreas or the Hayward faults.

Note that the above mapping does not consider site-specific conditions, such as on-site fuels or fire protection features, or neighboring large accumulations of fuels or hazardous operations. Consideration of these is beyond the scope of the present project – we recommend these be addressed by (i) identification of most critical SFPUC facilities, and (ii) for those most critical facilities, conducting a site-specific fire protection survey.

2.6 Wear and tear.

This hazard is SFPUC facility-specific and has been tabulated in the Phase I report and worksheets. Section 3 presents system schematics marked per the information in the Phase I report.

Wear and tear was used in Phase I to describe a condition where age, special conditions or obsolescence effected the maintainability of a facility. Special conditions included soil corrosiveness and obsolescence described conditions such that parts or supplies were difficult or impossible to obtain.

2.7 Summary

Table 2-2 summarizes Hazard Events defined for this project.

---

[15] Scawthorn, C. and Khater, M.,1992. *Fire Following Earthquake - Conflagration Potential in the Greater Los Angeles, San Francisco, Seattle and Memphis Areas*, Natural Disaster Coalition, Boston MA (see www.ibhs.org). and Scawthorn, C. *Fire Following Earthquake - Estimates of the Conflagration Risk to Insured Property in Greater Los Angeles and San Francisco.* 1987. All-Industry Research Advisory Council, Oak Park IL.

TABLE 2-2
SUMMARY OF HAZARD EVENTS

HAZARD	HAZARD EVENTS
Earthquake	Five events: San Andreas, Hayward, Calaveras (N), Greenville, Great Valley FZ (see Table 2-1)
Ground shaking	Peak Ground Acceleration for each earthquake hazard event, and probabilistic '475 year' PGA
Fault Rupture	At intersection of SFPUC facilities with each earthquake hazard event - displacements of several meters
Liquefaction Potential and Lateral Spreading	Areas of high liquefaction potential are identified.
Landslide	Areas of high landslide potential are identified
Flood	FEMA '100 and 500 year' floodplains are identified
Fire	Areas of Potential Large Wildland Fire and Urban Conflagration
Age, wear and tear	Mapped per Phase I report

3 DEVELOPMENT OF HAZARD MAPS

This section presents hazard maps and their basis.

3.1 Approach to mapping

The entire SFPUC water distribution system has been digitized into the MapInfo GIS system and is shown in Figures 3.1 through 3.4.

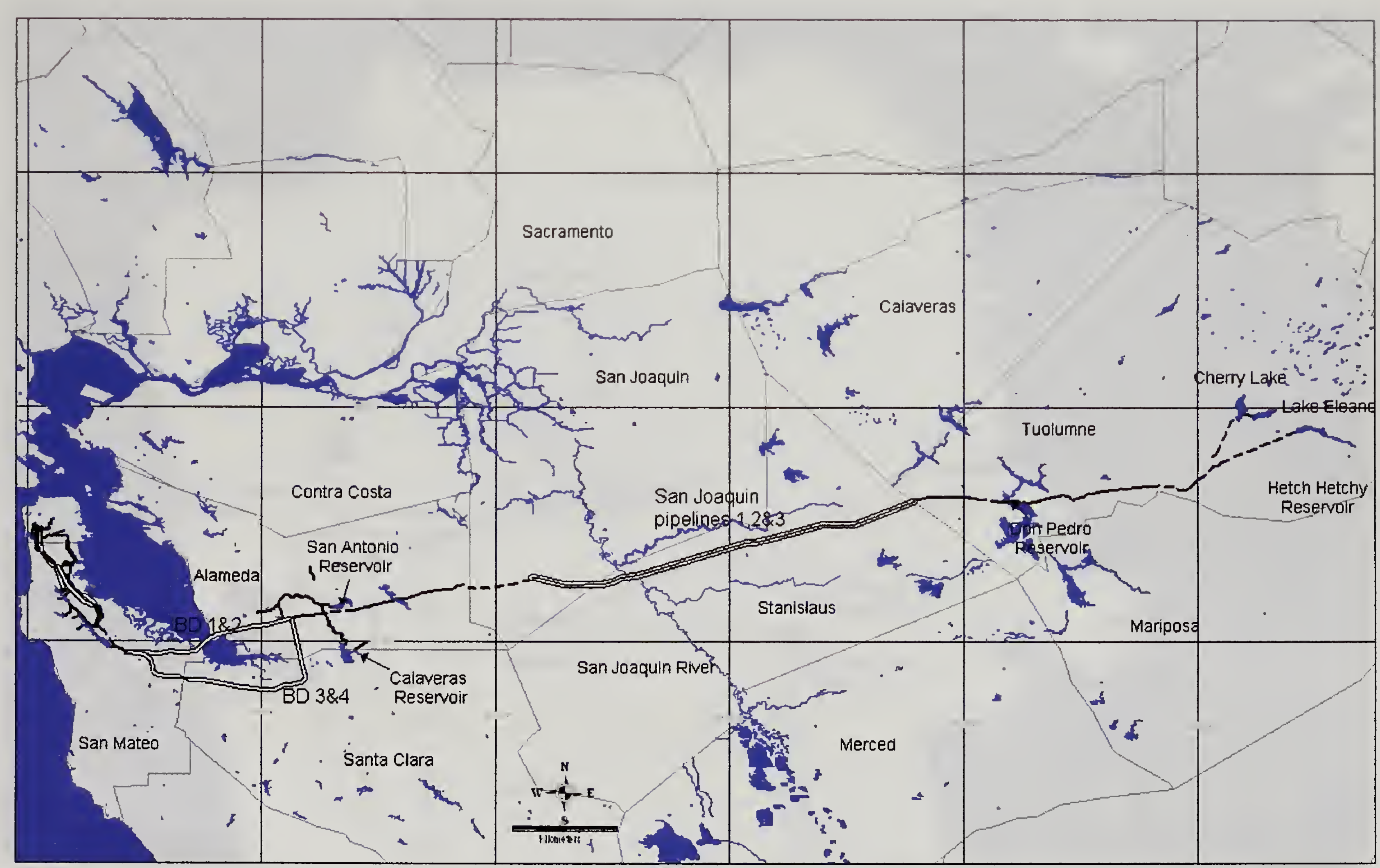


Figure 3.1: SFPUC water distribution system

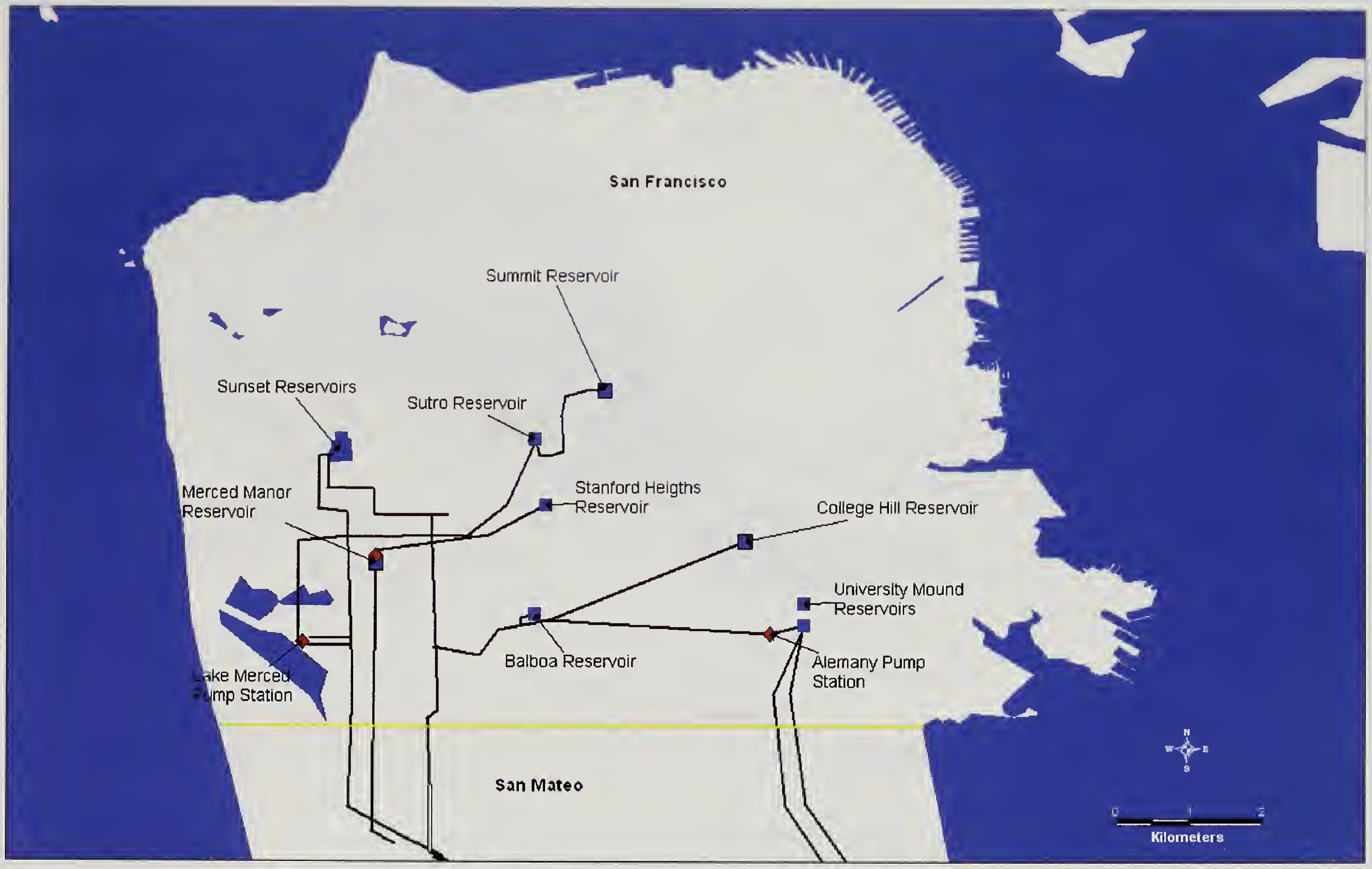


Figure 3.2: View of the SFPUC system in the city of San Francisco.

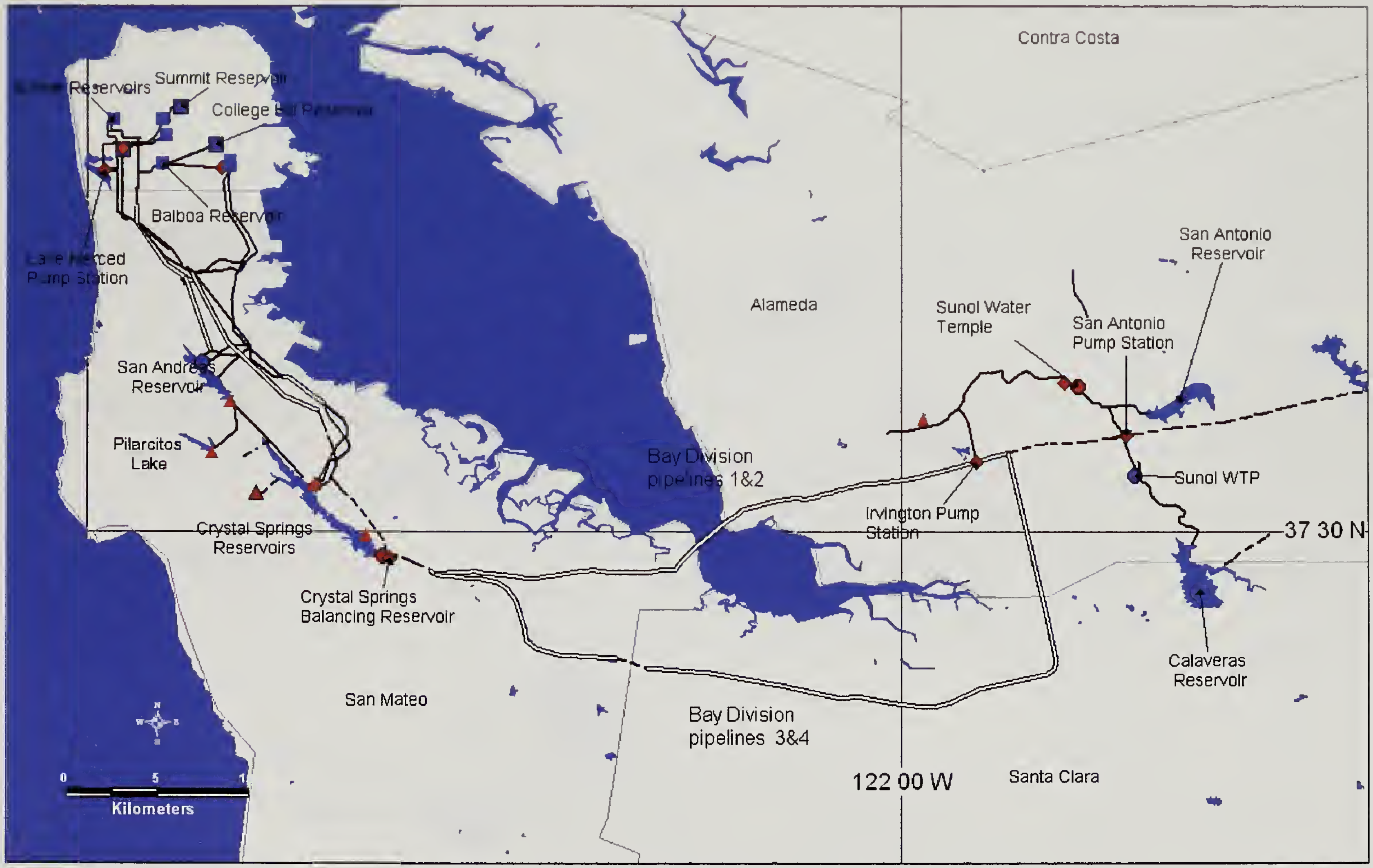


Figure 3.3: View of the SFPUC system from San Francisco to Sunol Filtration Plant.

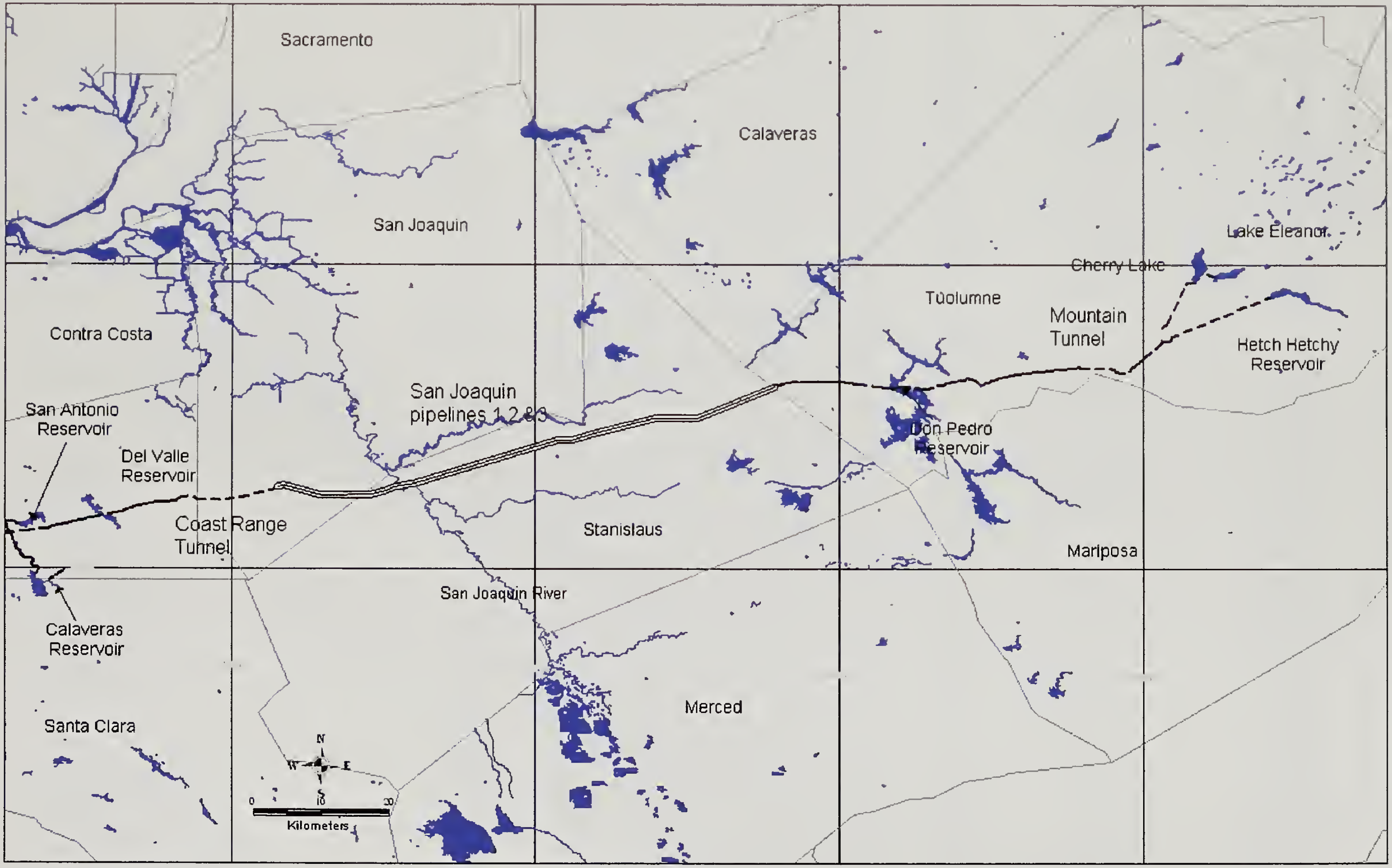


Figure 3.4: View of the SFPUC system from Sunol Filtration Plant to Hetch Hetchy Reservoir.

Hazard maps were collected from different sources in GIS format and combined with the SFPUC system, to develop maps of the hazard events as described above.

3.2 Earthquake map

Several measures are mapped regarding earthquake hazard. These measures are: i) liquefaction potential, ii) faults, iii) 475-year probabilistic ground shaking, and iv) five earthquake scenarios.

3.2.1 *Alquist-Priolo Fault Zones*

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. This state law was a direct result of the 1971 San Fernando Earthquake, which was associated with extensive surface fault ruptures that damaged numerous homes, commercial buildings, and other structures.

The act's main purpose is to prevent construction of buildings used for human occupancy on the surface trace of active faults. The Act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards, such as ground shaking or liquefaction.

The law requires the State Geologist to establish regulatory zones (known as Special Study Zones) around the surface traces of active faults and to appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning and controlling new or renewed. Local agencies must regulate most development projects within the zones. Projects include all land divisions and most structures for human occupancy. Single family wood-frame and steel-frame dwellings up to two stories not part of a development of four units or more are exempt. However, local agencies can be more restrictive than state law requires. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. An evaluation and written report of a specific site must be prepared by a licensed geologist. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault (generally 50 feet).

Figure 3.5 shows that the SFPUC system crosses several A-P faults and those portions of the system pose a risk for fault rupture.

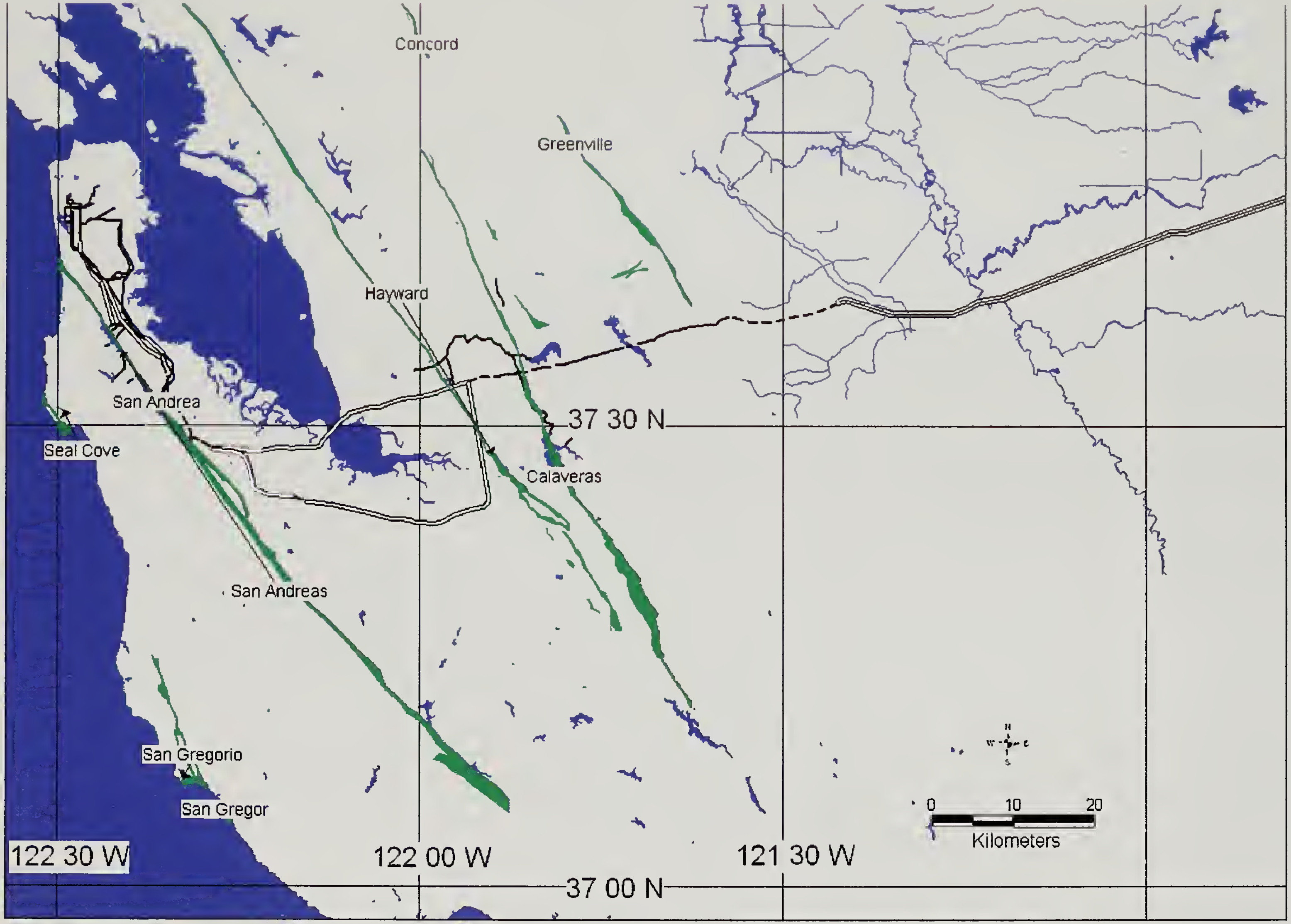


Figure 3.5: Map of the Alquist-Priolo faults and the SFPUC system (as of 1994)

3.2.2 Active faults according to the California Department of Mines and Geology.

Figure 3.6 shows the SFPUC system and the location of active faults according to the California Department of Mines and Geology (CDMG) whose rupture movement may affect directly the SFPUC system. The faults shown in this figure have been used by CDMG geologists to develop seismic hazard probabilistic maps for the state of California.

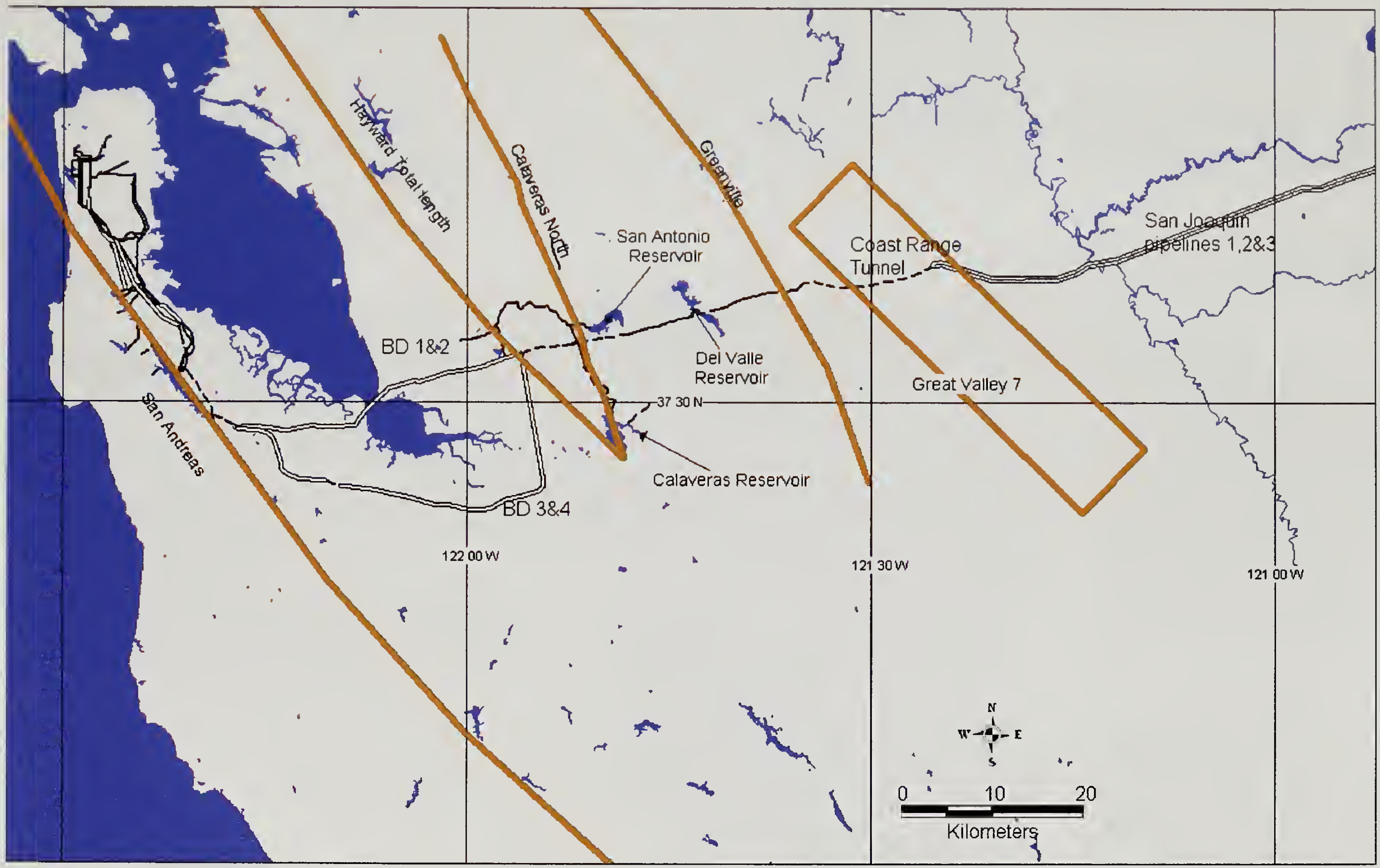


Figure 3.6: Map of active faults crossing the SFPUC system.

3.2.3 *Liquefaction susceptibility*

Figure 3.7 shows a digitized map with areas of Very Low, Low, Moderate, High and Very High susceptibility of soils to liquefy should an earthquake event occur. Areas marked Very High and High in this figure are expected to liquefy in an earthquake of magnitude 6.5 or greater. Areas marked as Moderate are expected to liquefy in a magnitude 8 event but not in a magnitude 6.5 event. Low and Very Low will not liquefy, even in a magnitude 8 earthquake. It is expected that: (1) 80 percent of future liquefaction will take place in areas marked as High or Very High, (2) 20 percent or less in areas marked as Moderate and Low, and (3) less than 1 percent in areas marked as Very Low.

This map is a combination of maps developed from two different sources. Data corresponding to most of the western and northern portions of the San Francisco Bay area corresponds to the USGS Open File Report 97-715. On the other hand, data collected for the eastern sections of the SFPUC system and the south bay has been extracted from an existing liquefaction susceptibility map developed for the Association of Bay Area Governments (ABAG). Liquefaction susceptibility in these maps has been assessed on the basis of four factors: (1) presence of loose, cohesionless, sandy or silty deposits within 50 feet of the surface, (2) presence of groundwater that saturates these deposits, (3) historical records of liquefaction during previous earthquakes, and (4) limited borehole [standard penetration test (SPT)] data and the modified Seed-Idriss[16] approach to evaluating liquefaction susceptibility. Currently, an updated map of liquefaction susceptibility of the entire bay area is being developed by William Lettis &Associates, Inc. for ABAG under a USGS grant and is expected to be publicly available as early as July 1999. It is encouraged the future use of this newly developed map as a substitute of Fig.3.7.

---

[16] Seed, H. and Idriss, I. (1982) Ground motions and soil liquefaction during earthquakes. *Earthquake Engineering Research Institute*, Engineering Monograph v.5, 134p.

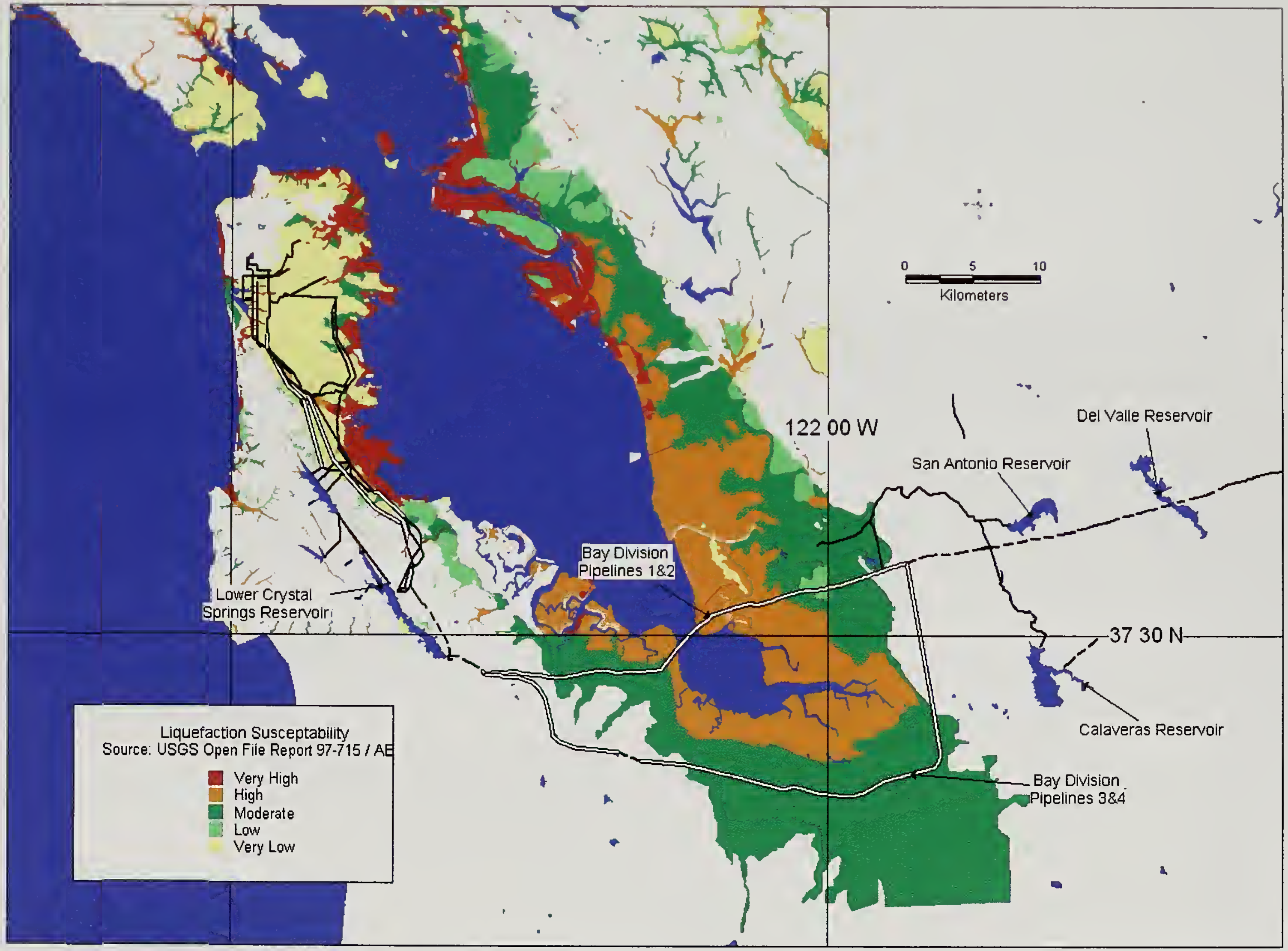


Figure 3.7: Map of liquefaction susceptibility in the Bay Area.

3.2.4 *Probabilistic map*

Figure 3.8 shows the 475-year probabilistic ground shaking hazard map. The ground shaking is expressed as fraction of the acceleration of gravity, ie, a zone with 0.2 means that the horizontal acceleration in that zone is 20% of the acceleration of gravity (in other words 1.98 m/sec^2 or 6.44 in/sec^2). The source of data is the USGS Open File Report 96-706.

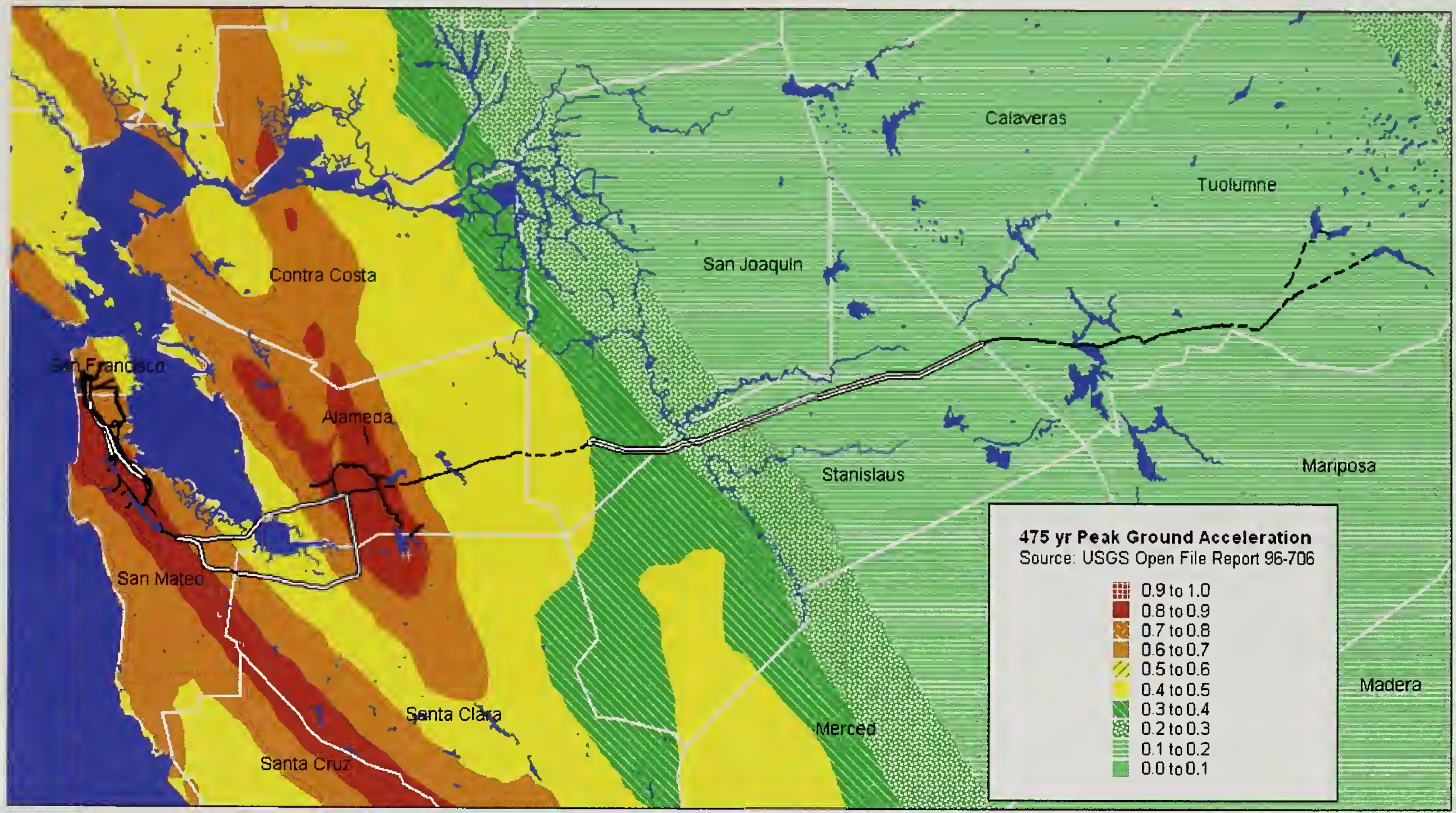


Figure 3.8: Probabilistic ground shaking hazard map.

3.2.5 Earthquake scenarios

Figure 3.9-3.13 show the peak ground acceleration as a fraction of gravity for the earthquake scenarios listed in Table 2-1. These maps were developed at EQE International using the USQUAKE™ software.

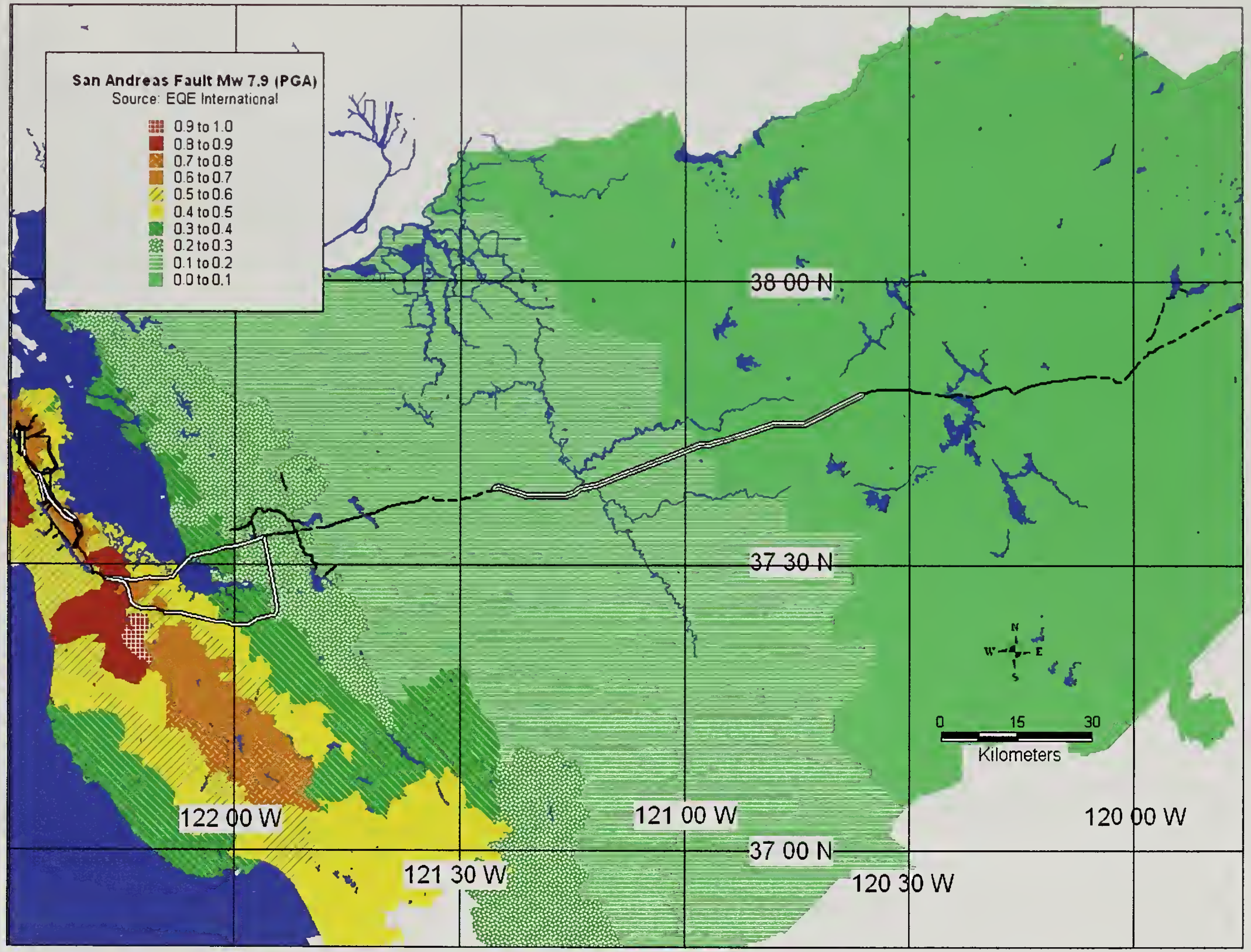


Figure 3.9: Peak ground accelerations from a San Andreas M_w 7.9 event.

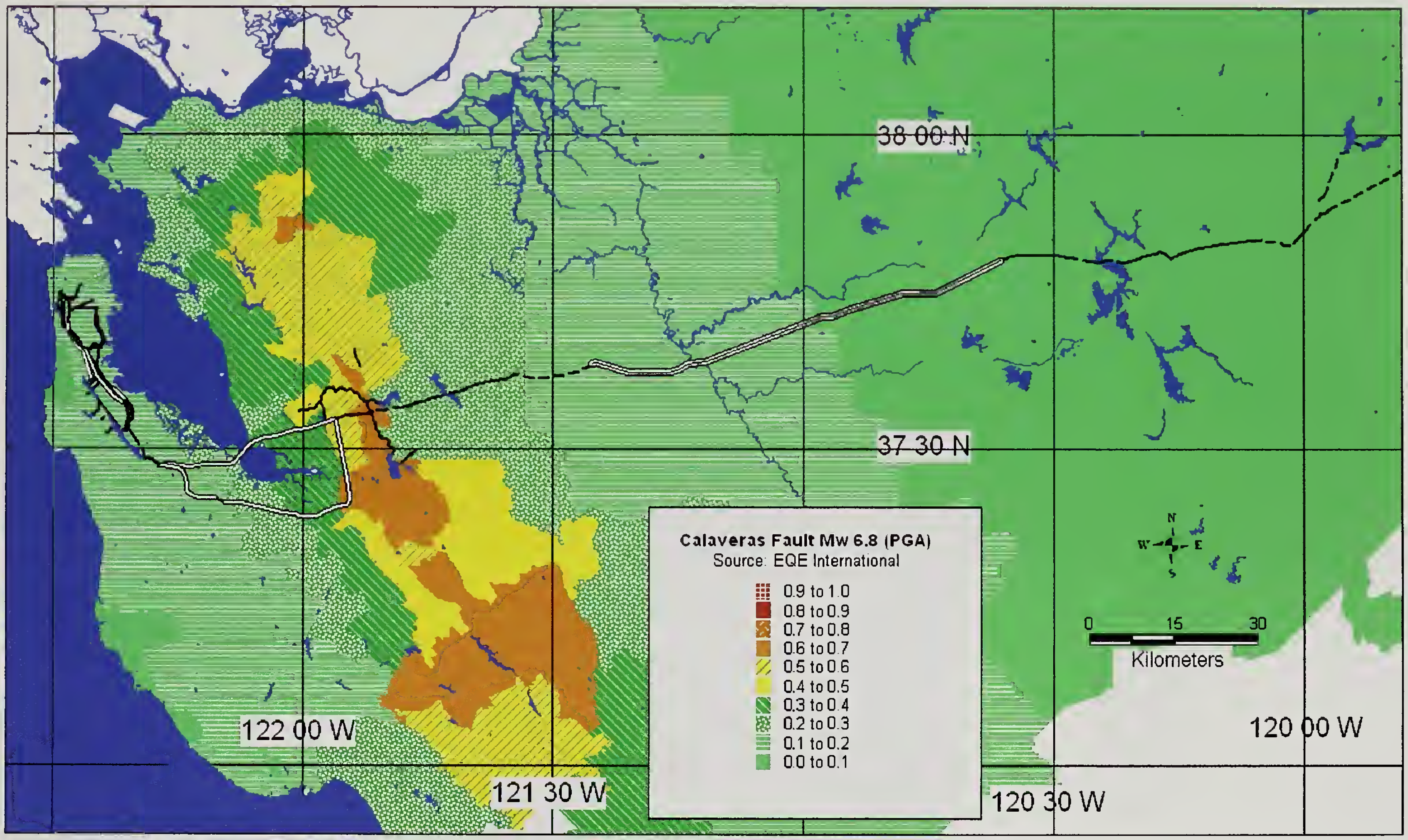


Figure 3.10: Peak ground accelerations from a Calaveras M_w 6.8 event.

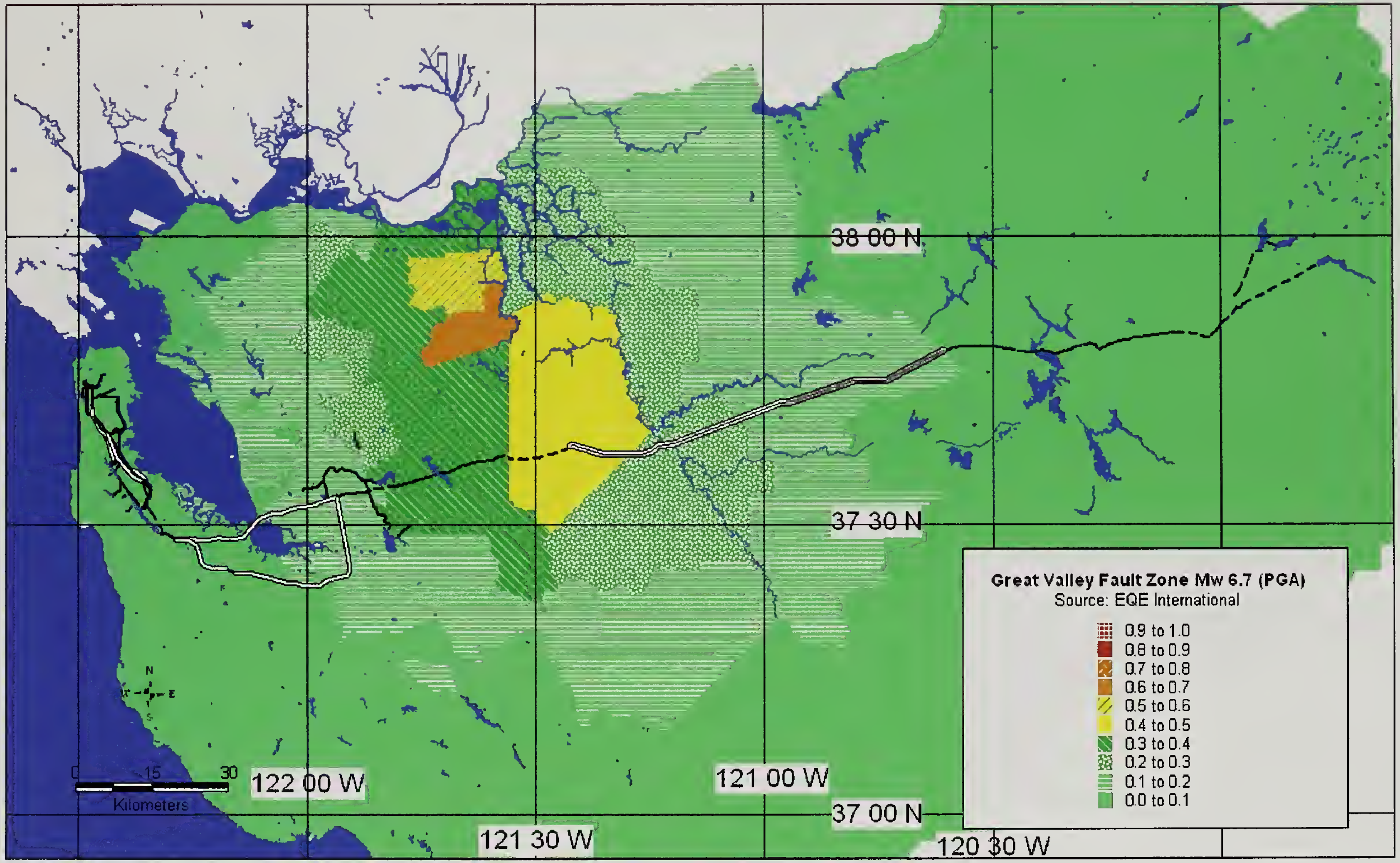


Figure 3.11: Peak ground accelerations from a Great Valley M_w 6.7 event.

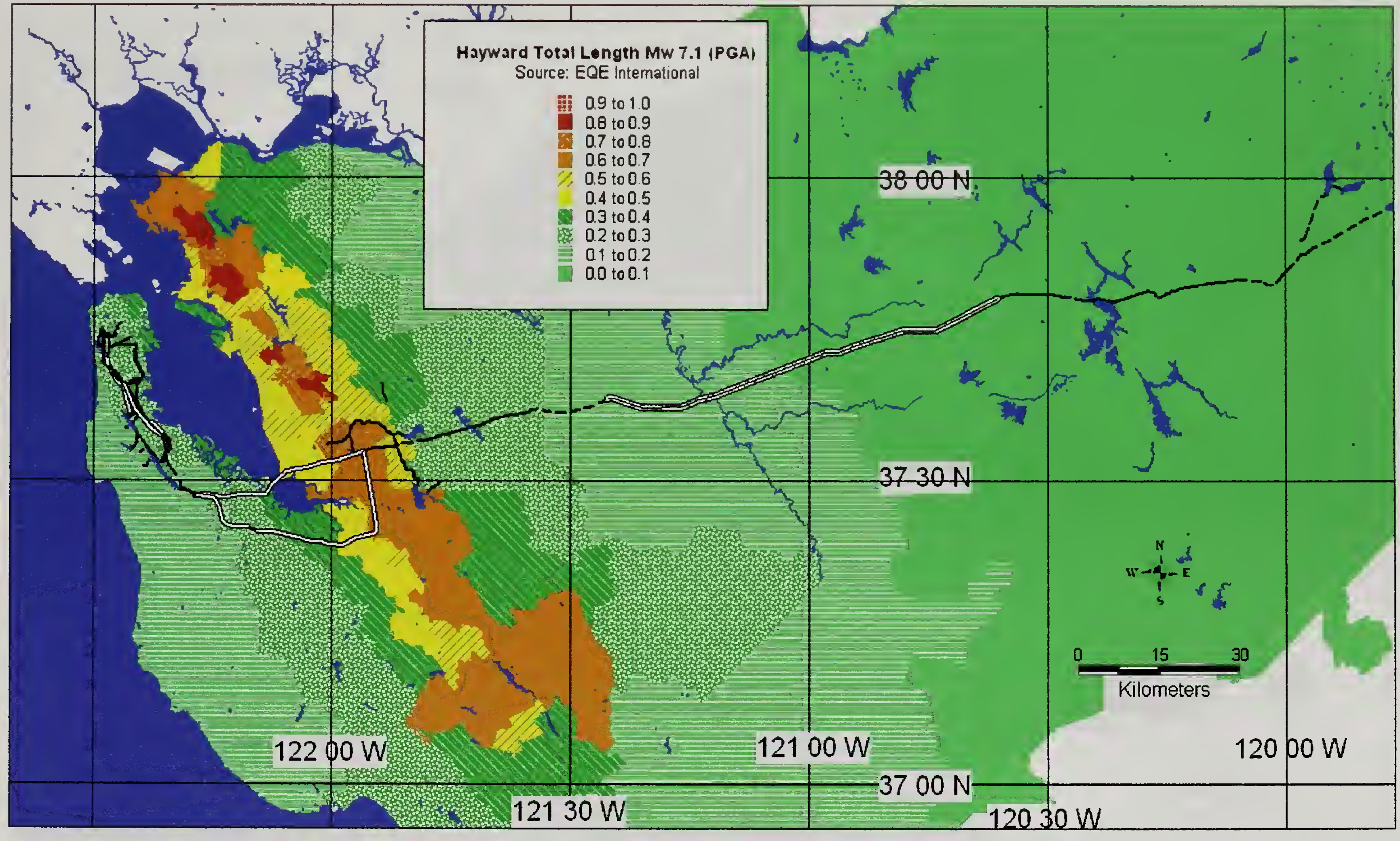


Figure 3.12: Peak ground accelerations from a Hayward M_w 7.1 event.

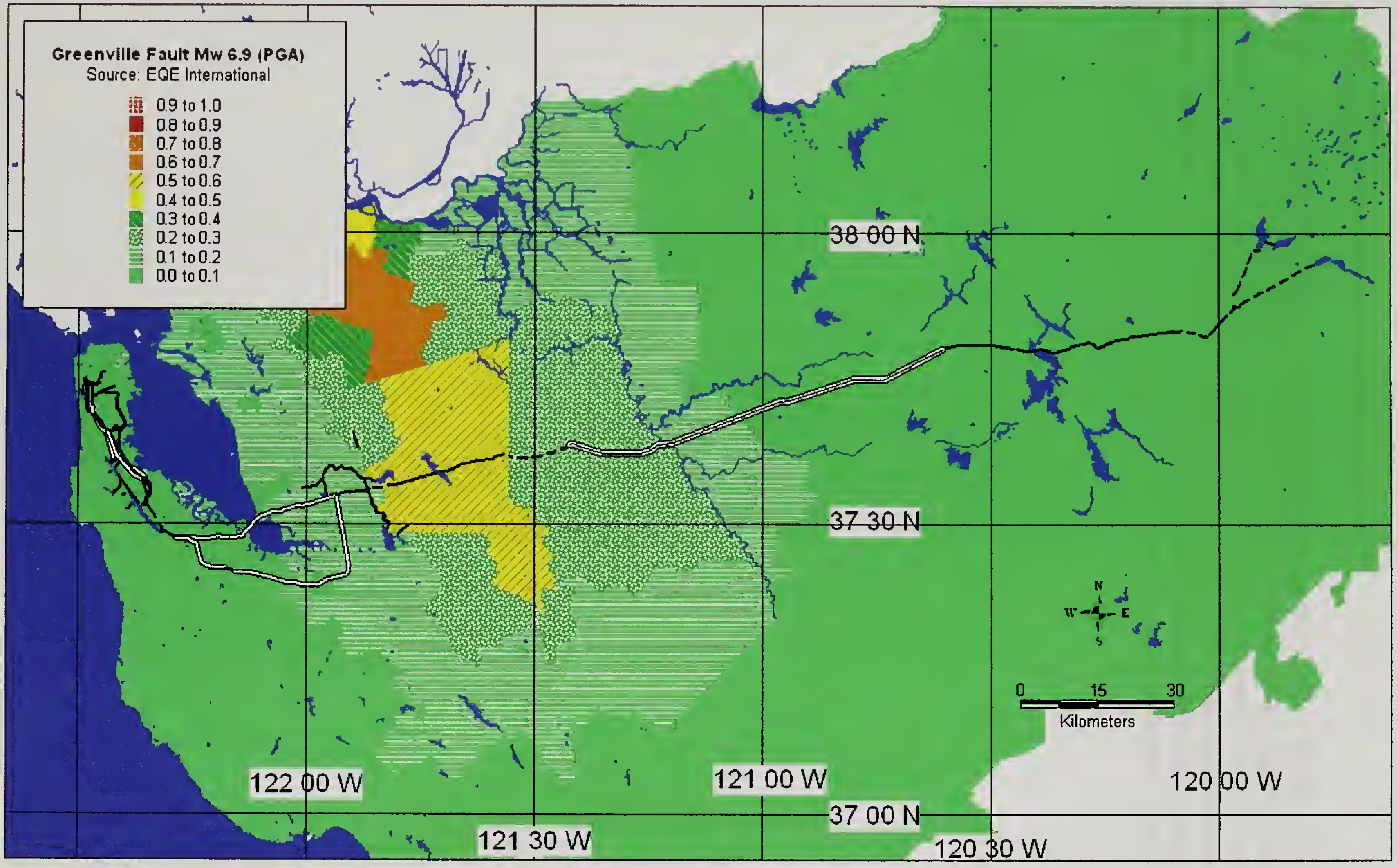


Figure 3.13: Peak ground accelerations from a Greenville M_w 6.9 event.

3.3 Flood map

Figure 3.14 shows the flood hazard map and its impact on the SFPUC system. This map is a digital form of the flood plain boundaries from Federal Emergency Management Agency's Flood Insurance Rate Maps (FIRM). This map shows the boundaries of the 100 and 500-year floods in the region. Floodplains mapping began in 1968 as an initiative from the Federal Insurance Administration and currently involves the technical expertise from the Corps of Engineers, USGS, SCS, TVA, NOAA, the Bureau of Reclamation and others. Figures 3.15-3.17 show the same information in more detail

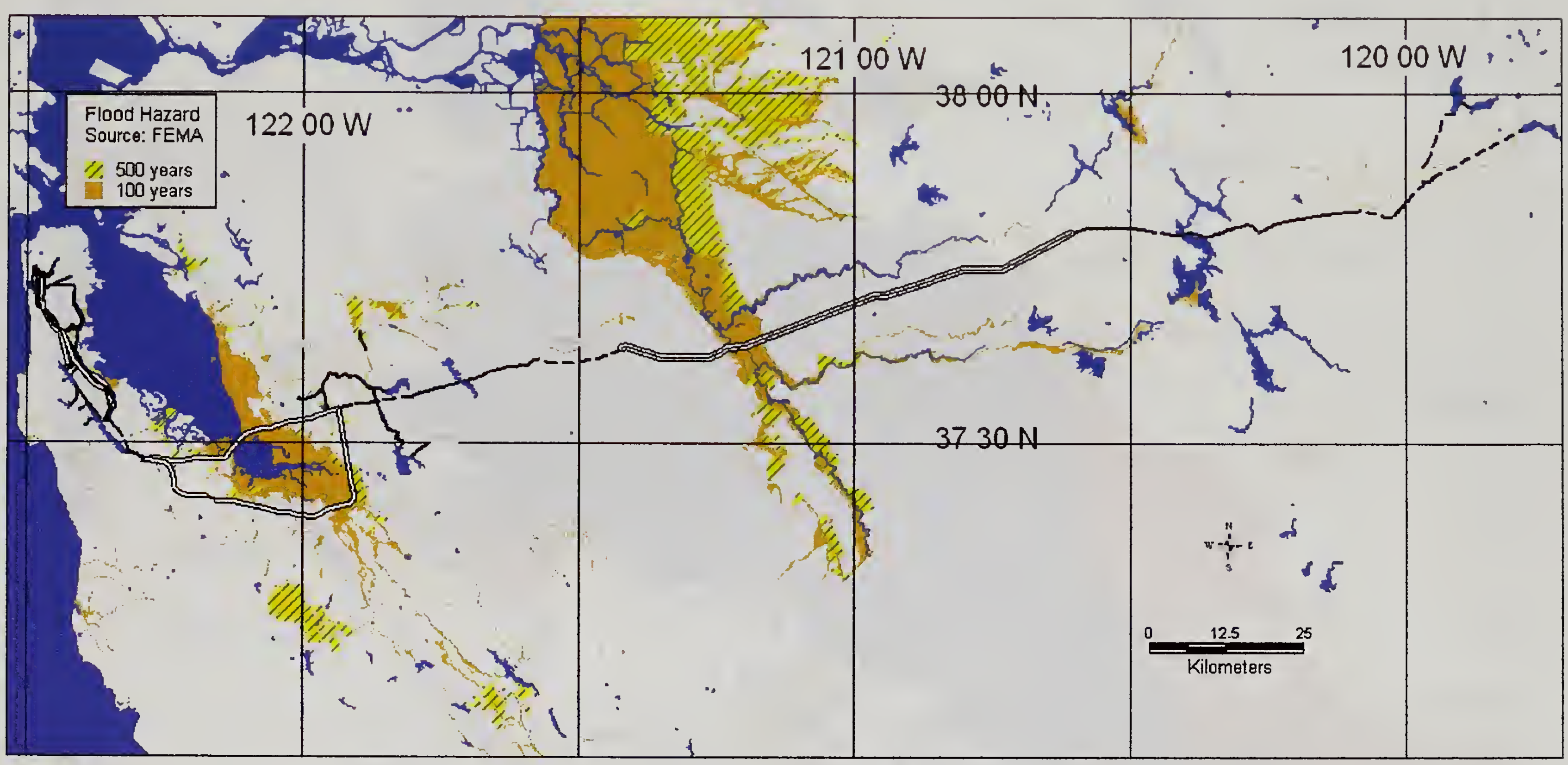


Figure 3.14: Flood hazard map and the SFPUC system

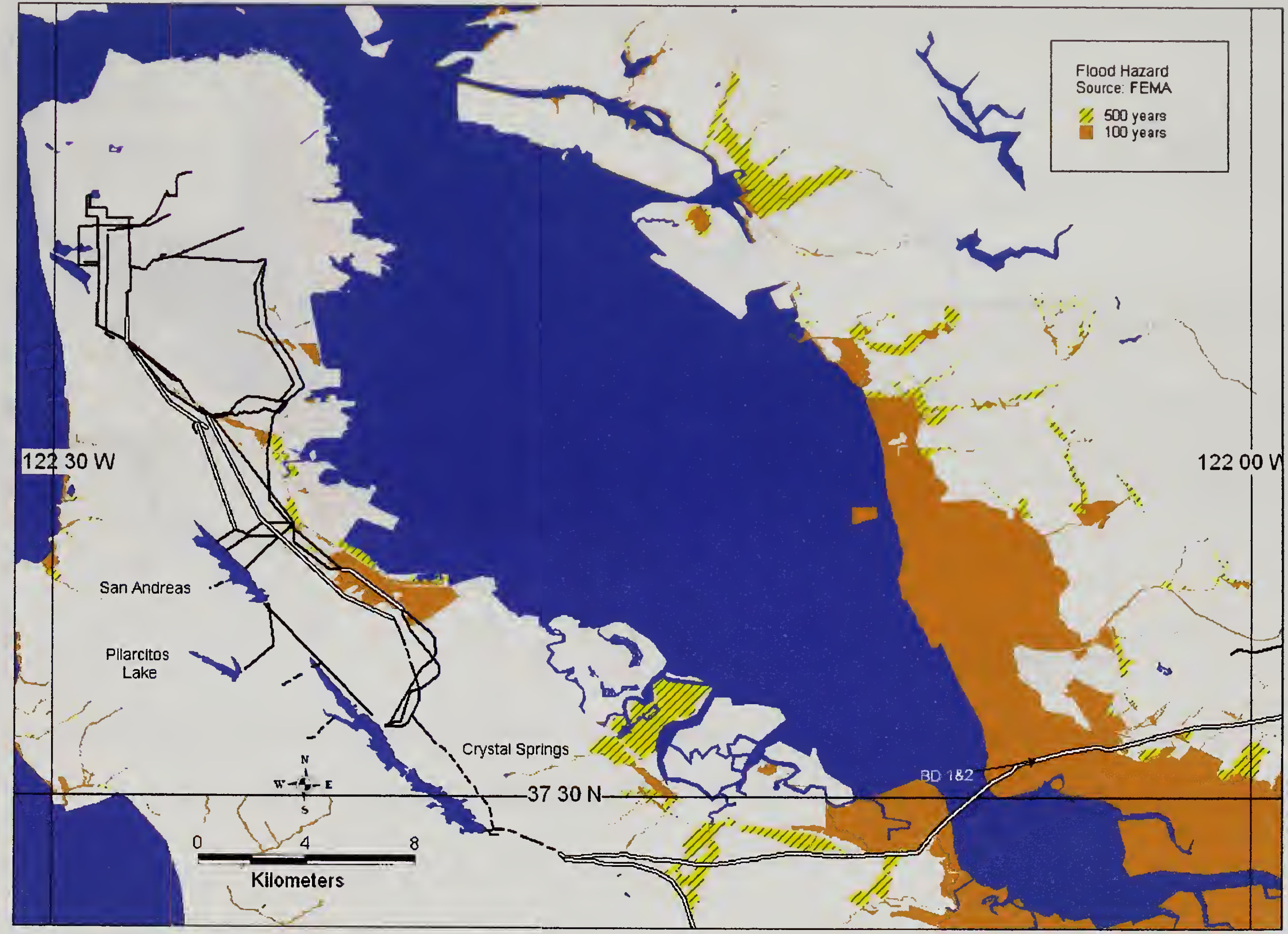


Figure 3.15: Flood hazard map and the SFPUC system - San Francisco and San Mateo Counties.

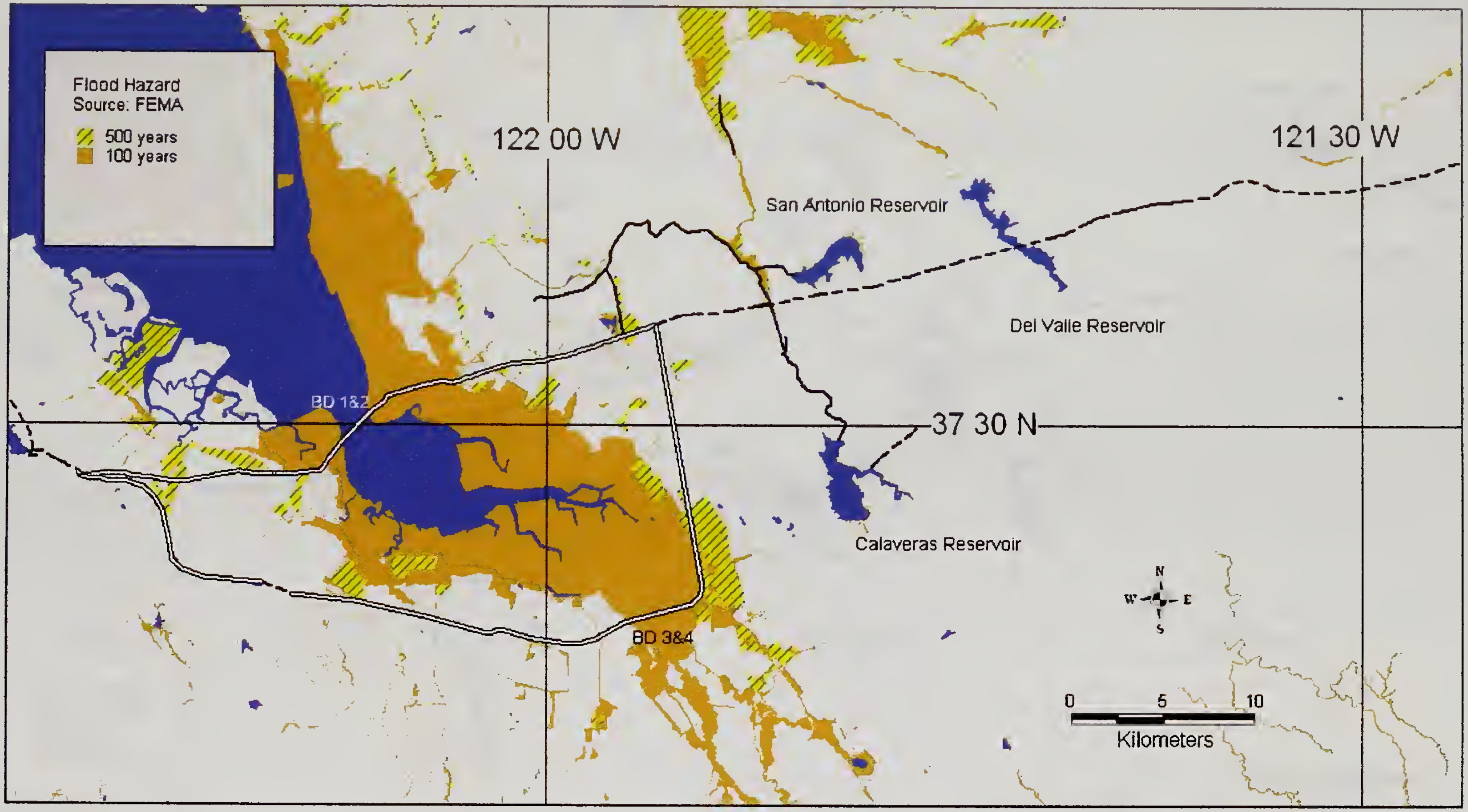


Figure 3.16: Flood hazard map and the SFPUC sys tem – South Bay and Sunol Valley.

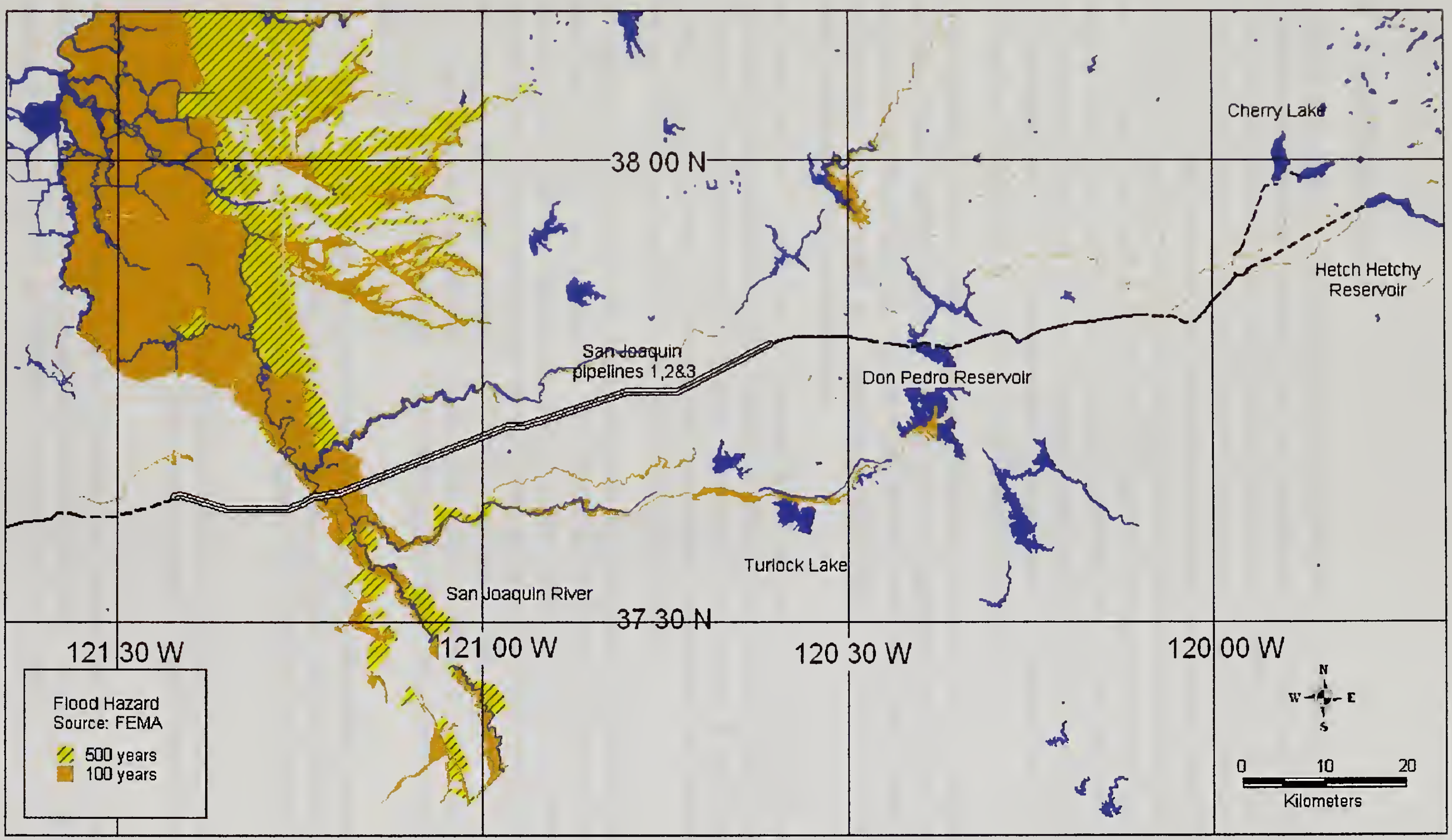


Figure 3.17: Flood hazard map and the SFPUC system – Sierras.

3.4 Fire Hazard maps

Wildland Fire Hazard The approach taken to evaluate the vulnerability of fire hazard was to define the predicted fire behavior for the watersheds. Analysis was performed using BEHAVE, a computerized fuel and fire behavior prediction model developed by the USDA Forest Service at the Intermountain Forest Fire Research Laboratory. BEHAVE integrates the factors of topography, fuels, and weather for any one time based on heat transfer algorithms. Results of the model are predictions of flame length, rates of spread, fireline intensity, and heat per unit area. To depict the spatial distribution of hazards an output of flame length in meters is mapped and shown in Fig. 3.18. The data shown in this figure is the result of a study conducted by Wildland Resource Management Incorporated. It is also identified in Fig.3.18 as large triangles the SFPUC watersheds with significant fire hazard potential. This information has been extracted from the SFPUC Watershed Sanitary Survey.

The spatial distribution of the flame length allows managers and investigators to see, for example, where facilities may be damaged from a significantly hot fire. Or, because heat output an important factor in determining natural resource damage (such as depth of water repellent layers in the soil), this factor may be combined with mapped soil erosion potentials to predict sediment in the water course.

The flame length of eight feet was determined to be level at which fire damage is likely to be significant. Flame length is highly related to heat output of a fire, and so can be used as a proxy which can be more easily interpreted by a variety of audiences. A fire's heat output is not only related to natural resource damage, but also ease of suppression and possible ignition or damage to structures and other facilities in the right-of-way.

The majority of the area in the study area has the potential for producing flame lengths greater than 8 feet. Slightly more than one-third (34%) of the study area is predicted to produce no flame lengths; these are likely to be water bodies, cultivated lands, or urban areas. Approximately 12 percent has predicted flame lengths of less than eight feet in flame length, and are generally those wildlands which have sparse, moist, vegetation in flat locations. These are classified as non-hazardous. Almost half (49%) of the study area has predicted flame lengths of eight to fourteen feet. Less than ten percent (6.7%) of the study area is expected to produce flames from 14 to 45 ft.

The portions of the study area which are most uniformly hazardous are the hills between the Calaveras watershed and the Central Valley, the foothills east of Oakdale to Don Pedro Reservoir, and between Don Pedro to the split in the right-of-way between Cherry Lake and Hetch Hetchy Reservoir.

A large percentage of the area east of the split between the South and Middle Fork of the in the Tuolumne River does not produce flame lengths greater than 8 ft and thus are not classified as hazardous.

The Central Valley has large patches classified as non-hazardous. It is likely locations adjacent to these non-hazardous areas produce flames under 14 ft. The urban area in the western portion of the pipeline is similarly not classified as hazardous.

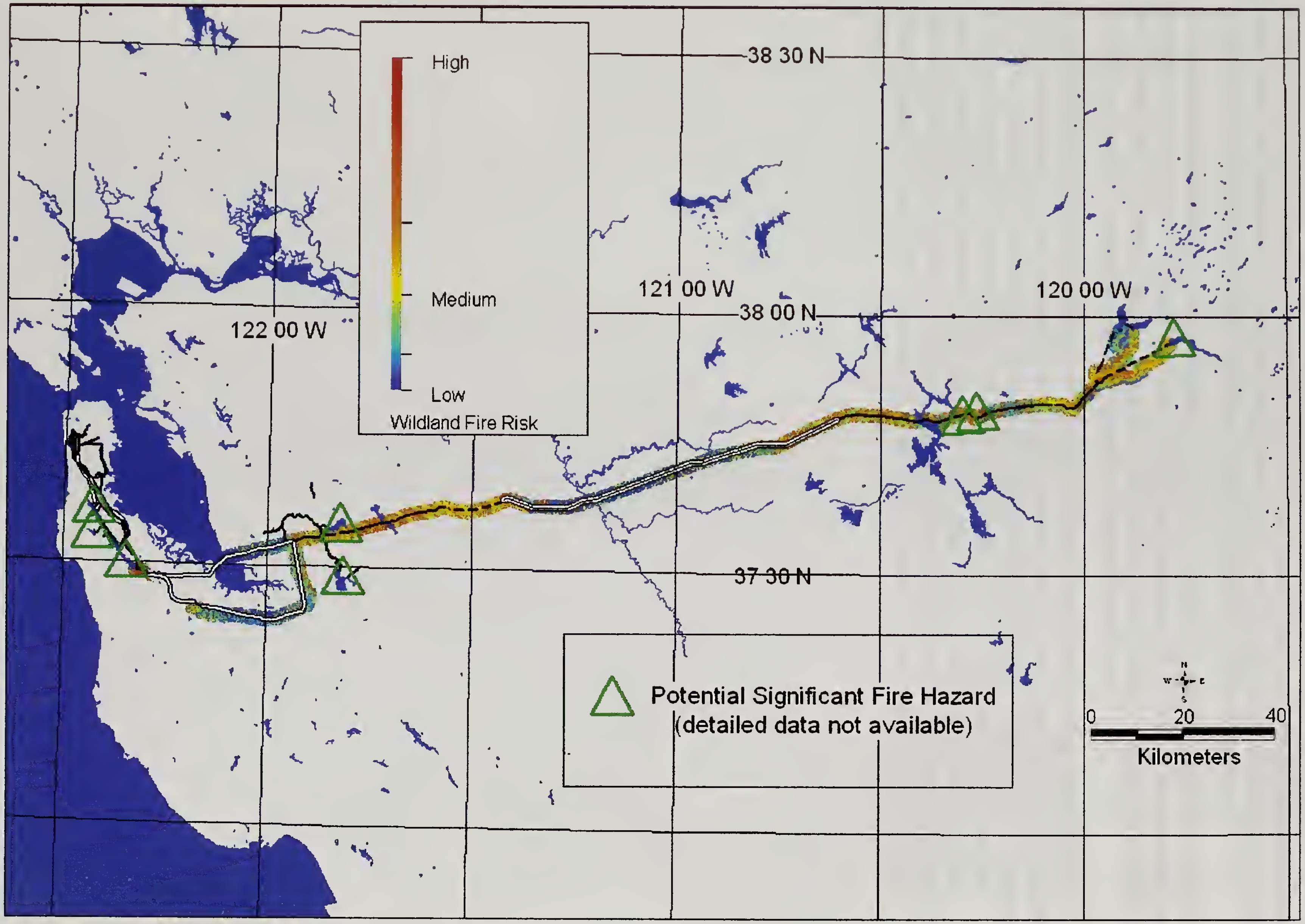


Figure 3.18: Wildland Fire hazard map and the SFPUC system

In the area west of Livermore, where the right-of-way splits, there is a fine-grain distribution of areas which are expected to flame lengths greater than 8 feet. In this situation, small patches of hazardous areas are interspersed with small patches of non-hazardous situations.

The total area included in this classification of high fire hazard areas may be over-estimated because of two factors. All grasslands are mapped as ungrazed, thus grazed areas would be falsely included in the high hazard locations. Additionally, the weather conditions used may be extremely rare events in the high elevations within the watershed.

Urban Fire Hazard has been mapped based on work performed by EQE International for the insurance industry, which accounts for building density and construction, fire protection and general capability of water supply systems to furnish large fire flows. Figure 3.19 is a mapping of the areas in the San Francisco Bay Area, showing Low to Very High areas of urban fire hazard. Very High is defined as greater than 10% losses given a large urban fire, such as following a major earthquake or under adverse meteorological conditions; High is defined as losses between 1% and 10%; Moderate as between 0.2% and 1%; and Low as less than 0.2% losses.

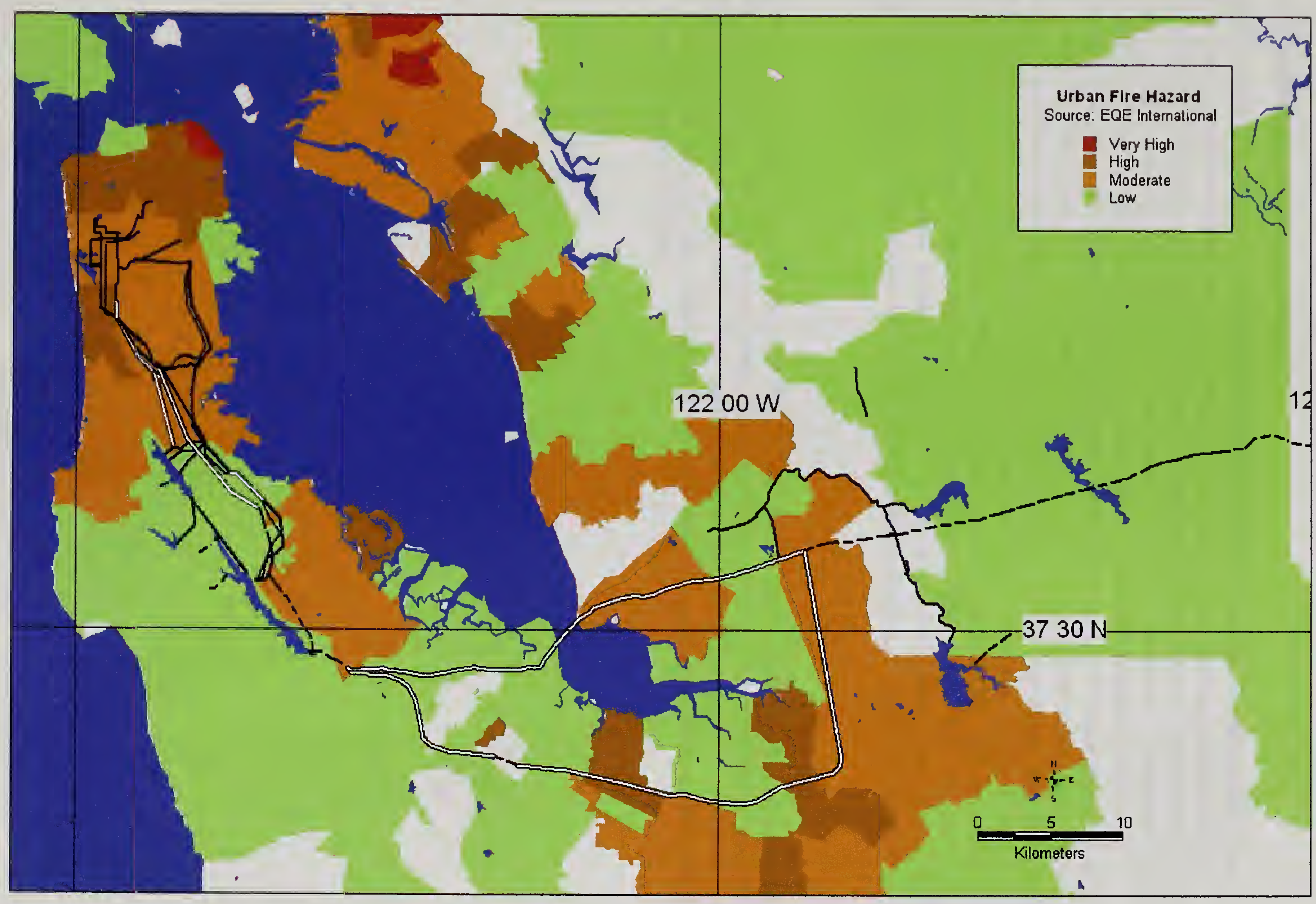
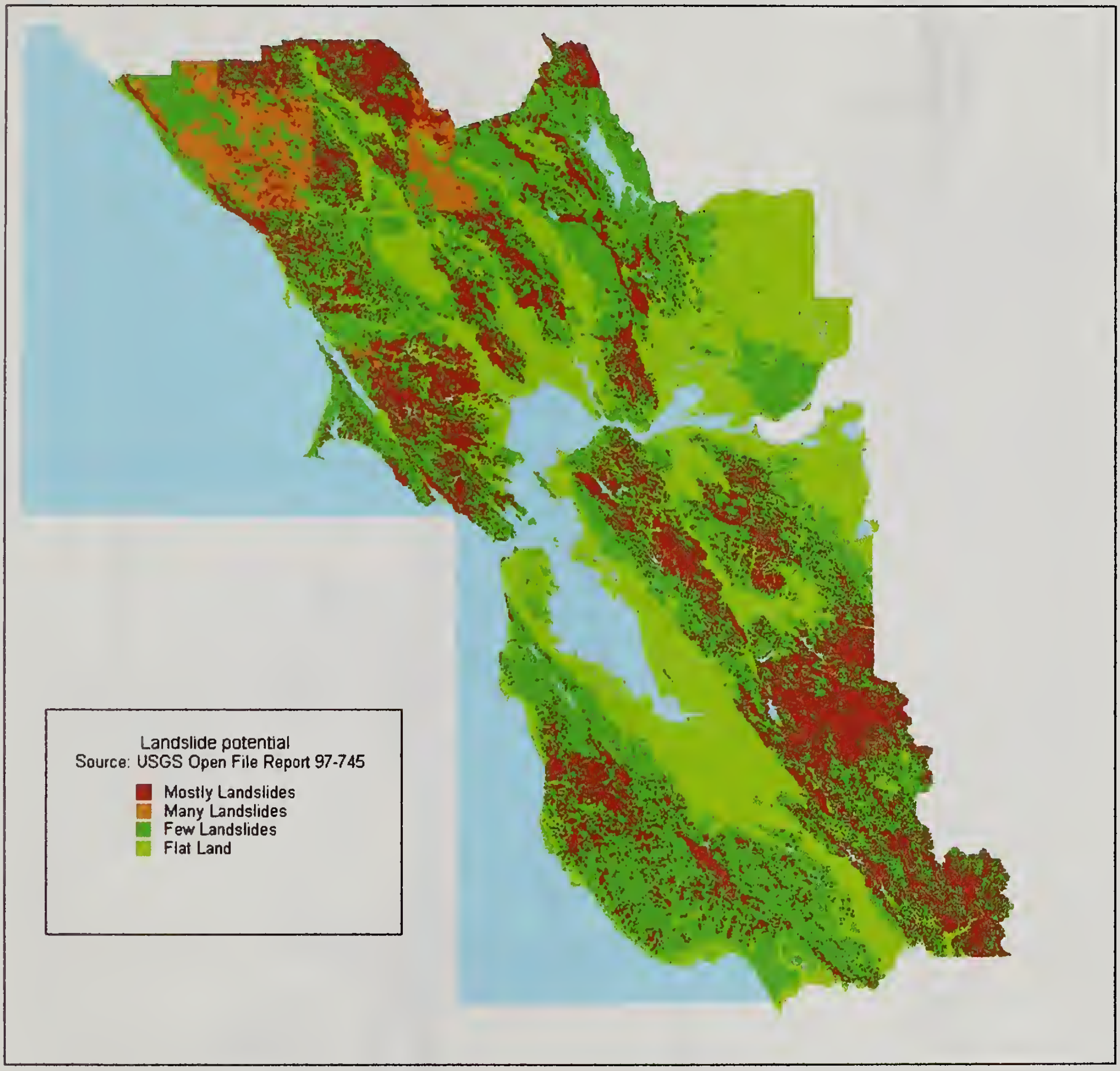


Figure 3.19: Urban Conflagration and Fire Following an Earthquake Potential and the SFPUC system.

3.5 Landslide, and wear and tear.

Figure 3.20 shows a map of debris-flow landslides sources in the San Francisco Bay Area. Areas marked as Mostly Landslide consists of mapped landslides, intervening areas typically narrower than 1500 feet, and narrow borders around landslides; defined by drawing envelopes around groups of mapped landslides. Areas marked as Many Landslides - consists of mapped landslides and more extensive intervening areas than in 'Mostly Landslide'; defined by excluding areas free of mapped landslides; outer boundaries are quadrangle and County limits to the areas in which this unit was defined. Few Landslides represents areas that contain few, if any, large mapped landslides, but locally contains scattered small landslides and questionably identified larger landslides; defined in most of the region by excluding groups of mapped landslides but defined directly in areas containing the 'Many Landslides' unit by drawing envelopes around areas free of mapped landslides. Finally, Flat Land areas have gentle slope at low elevation that have little or no potential for the formation of slumps, transnational slides, or earth flows except along stream banks and terrace margins; defined by the distribution of surficial deposits.

Figures 3.21 through 3.24 show maps of the SFPUC system and graphical representations of Phase I findings of risk to wear and tear. As in the Phase I study, critical facilities were ranked having low, medium or high risk. Each facility selected with Low are facilities that retain over 75% of its useful life; Medium if retain between 25% and 75%; and High if the facility retains less than 25% of its useful life.



Landslide potential
Source: USGS Open File Report 97-745

Figure 3.20: Map showing Landslide areas in the San Francisco Bay Area.

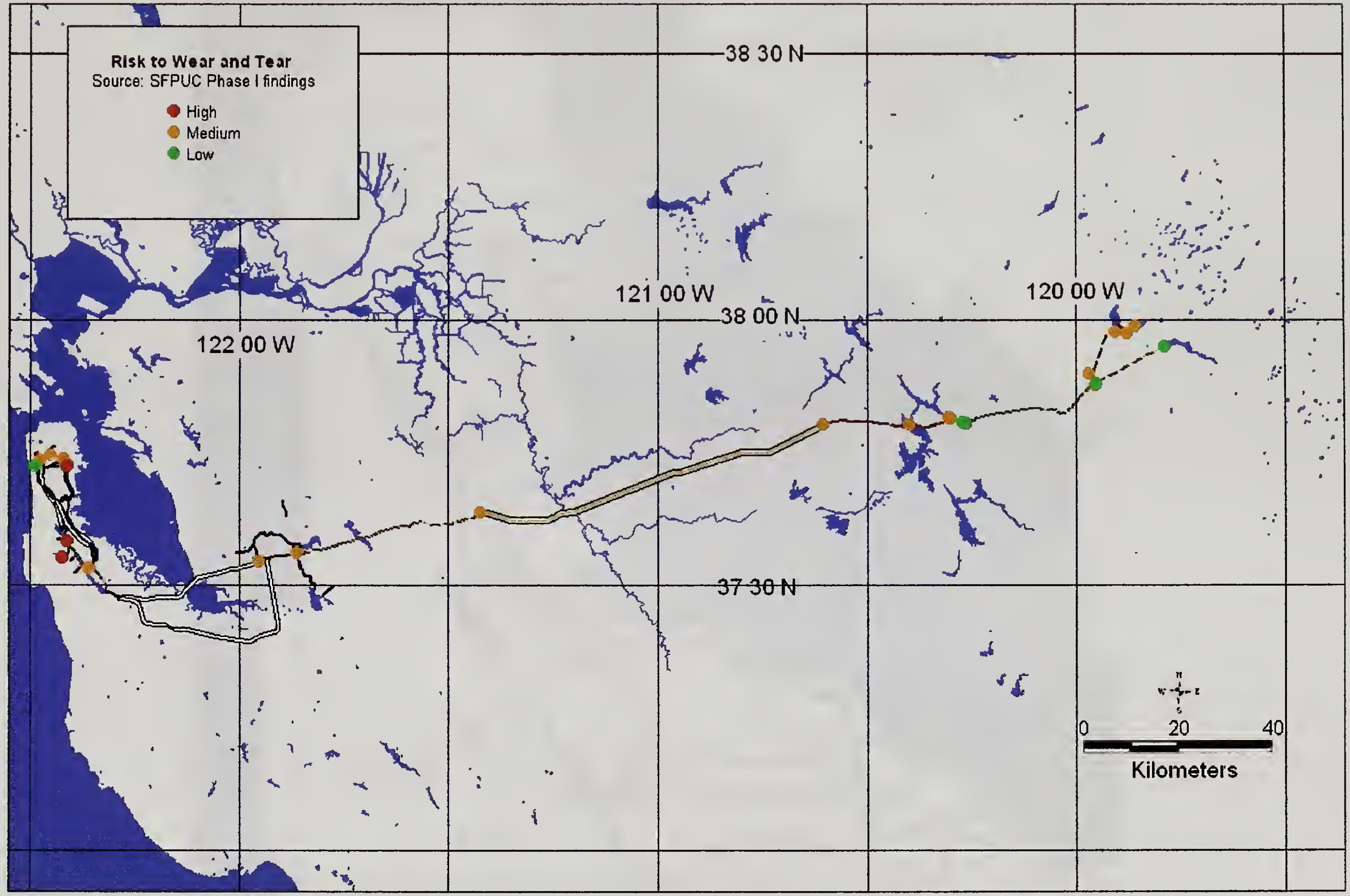


Figure 3.21: SFPUC facilities vulnerable to wear and tear.

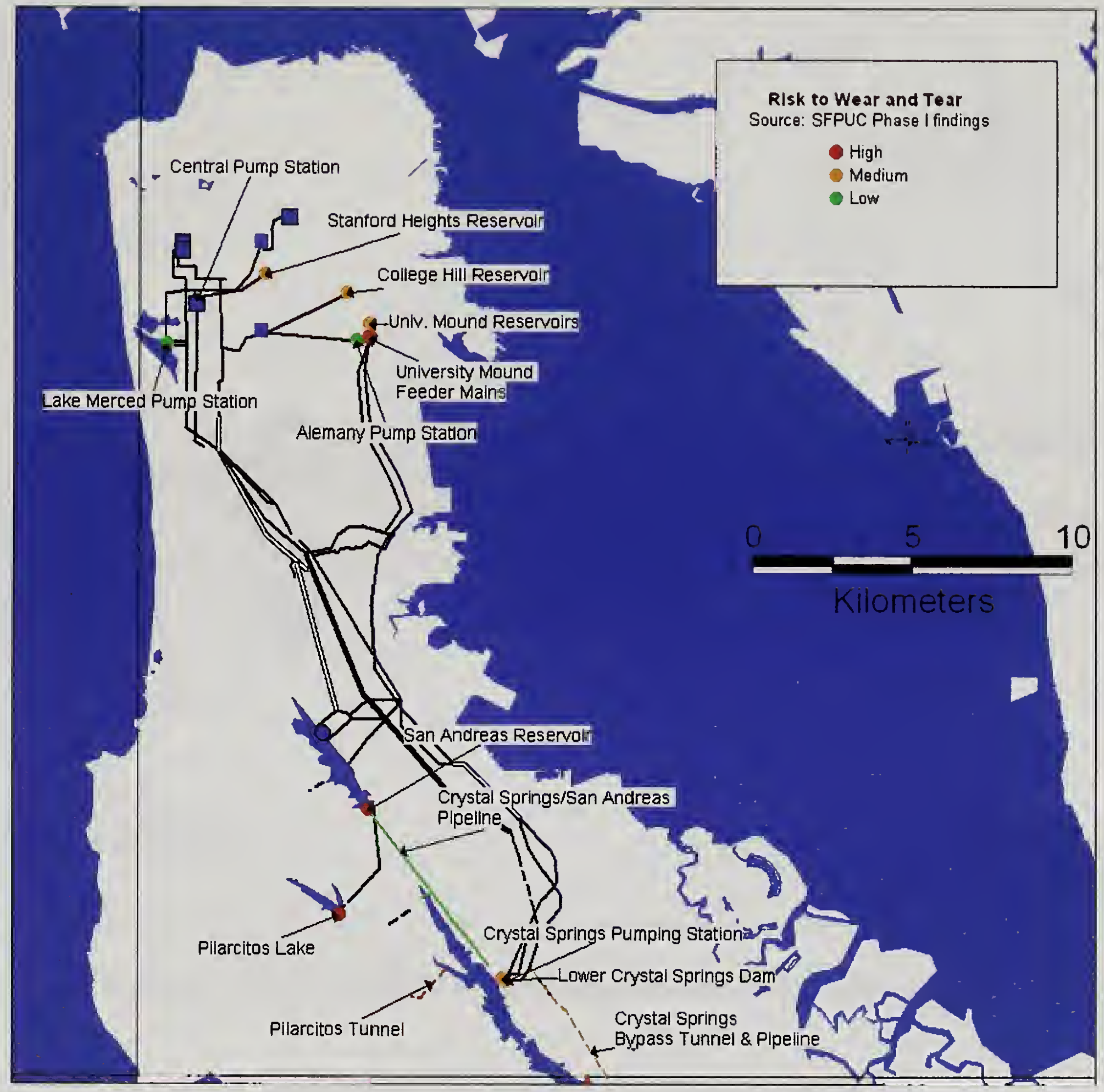

Risk to Wear and Tear
Source: SFPUC Phase I findings
● High
● Medium
● Low
0
5
10
Kilometers
Central Pump Station
Stanford Heights Reservoir
College Hill Reservoir
Univ. Mound Reservoirs
University Mound Feeder Mains
Lake Merced Pump Station
Alemany Pump Station
San Andreas Reservoir
Crystal Springs/San Andreas Pipeline
Crystal Springs Pumping Station
Pilarcitos Lake
Lower Crystal Springs Dam
Pilarcitos Tunnel
Crystal Springs Bypass Tunnel & Pipeline

Figure 3.22: SFPUC facilities vulnerable to wear and tear – View of the Peninsula.

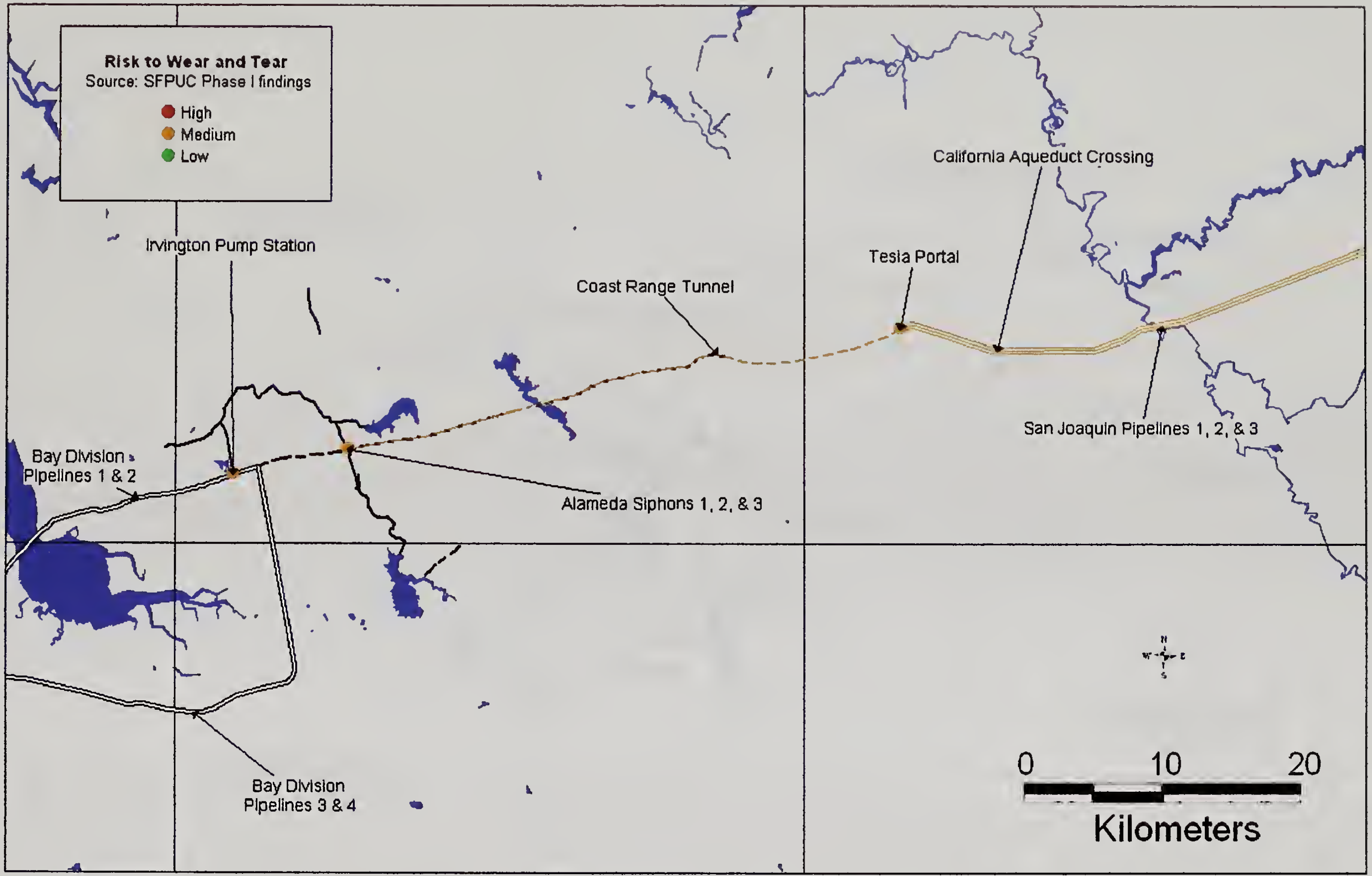

Risk to Wear and Tear
Source: SFPUC Phase I findings
🔴 High
🟠 Medium
🟢 Low
Irvington Pump Station
Coast Range Tunnel
Tesla Portal
California Aqueduct Crossing
San Joaquin Pipelines 1, 2, & 3
Bay Division Pipelines 1 & 2
Alameda Siphons 1, 2, & 3
Bay Division Pipelines 3 & 4
N
W
E
S
0
10
20
Kilometers

Figure 3.23: SFPUC facilities vulnerable to wear and tear – View of Sunol Valley.

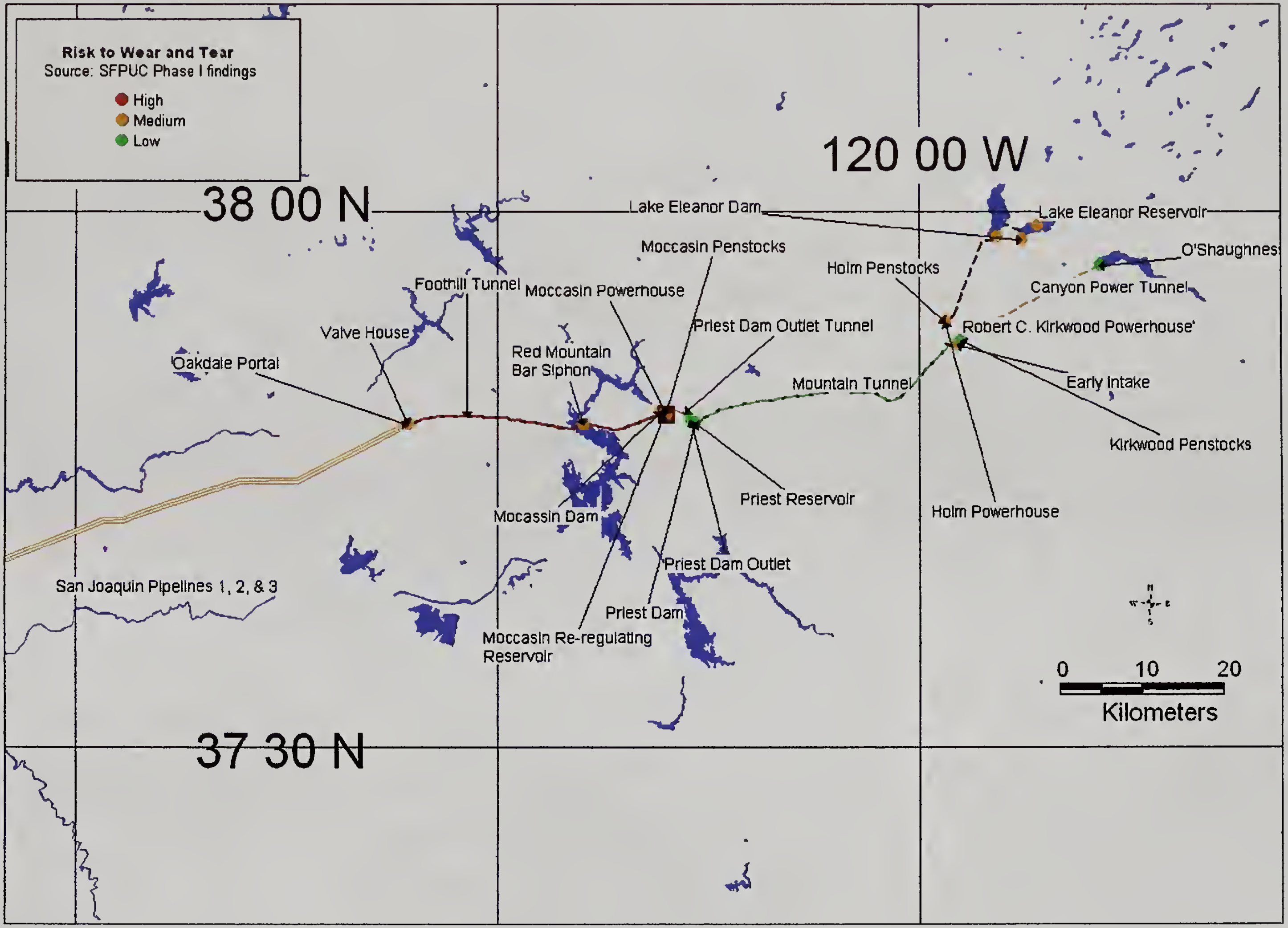


Figure 3.24: SFPUC facilities vulnerable to wear and tear – View of the Sierras.

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT: Technical Memorandum No. 2
Baseline Reliability Assumptions

PREPARED BY: The Water Reliability Partnership

DATE: June 28, 1999

BASELINE RELIABILITY ASSUMPTIONS

The San Francisco Public Utilities Commission (SFPUC) currently provides water to over 2.4 million people in the San Francisco Bay Area. The power generation system generates a significant amount of electricity for the City of San Francisco with the excess power sold to other utilities. Maintaining long-term public health and safety ensuring reliable water deliveries and securing the operation of critical facilities following seismic and other significant hazard events are fundamental objectives of the SFPUC in the SFPUC Facilities Reliability Program.

Many of the water and power system facilities are 60 to 80 years old and are exposed to a number of potential hazards, including major earthquakes. The SFPUC, in collaboration with the San Francisco Bay Area Water Users Association (BAWUA) is undertaking the program to address the reliability of its water and power systems during and following hazard events. In this context, reliability is defined as the ability of the system to meet requirements following a catastrophic event.

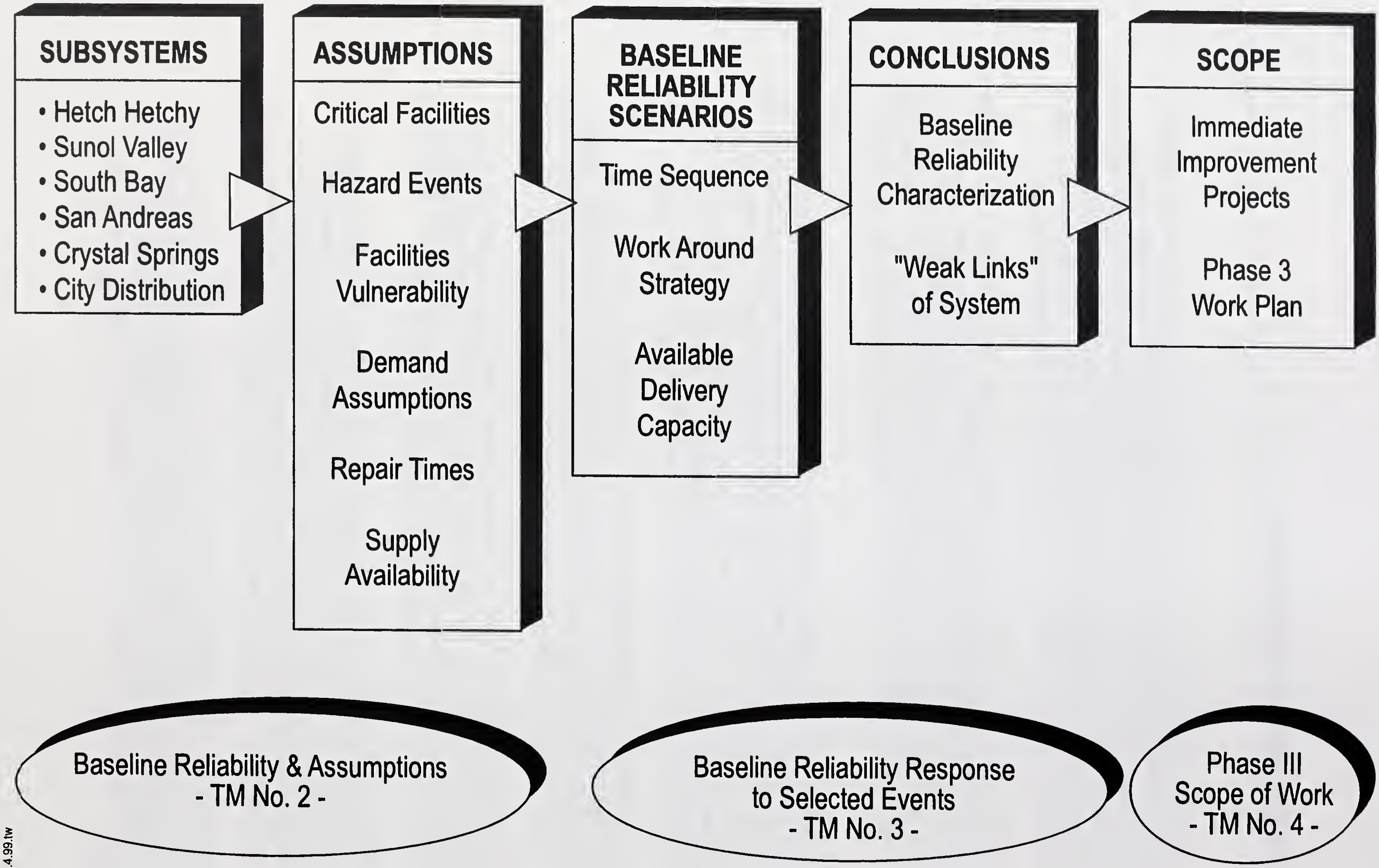
A key task of Phase II, Regional System Overview, is to describe the baseline reliability of the existing SFPUC system. The baseline reliability characterization will analyze, at a general level, the ability of the water system to meet system demands following an event, under existing facilities operation capabilities. During Phase III, the baseline reliability description will be revisited with more rigor to provide a basis for measuring the benefits of alternative improvements that may be proposed during this next, more detailed phase of the program.

Conducting a preliminary baseline reliability characterization during Phase II provides a framework for the Phase III analyses. Key assumptions that need to be made can be identified. In addition, the value of existing data can be confirmed and Phase III data needs identified. This information will be used during Phase II in developing the Phase III Scope of Work.

In order to assess the baseline reliability, assumptions were developed and are presented in this Technical Memorandum (TM) No. 2 along with the level of detail to be used for this general characterization. Many of the assumptions need further analysis for confirmation or for a greater level of detail; these recommended needs of Phase III are presented in this TM.

Technical Memorandum No. 3 presents a time sequence analysis of how the existing system may respond under selected hazard events. The baseline reliability scenarios were intended to be representative of major seismic events the SFPUC system would need to respond to, given its existing condition and configuration. An overview of the baseline reliability assessment process and the relationship between Phase II technical memoranda is presented in Figure 1.

As presented in TM No. 3, the reliability analysis provides a first order characterization of the existing system's reliability. The assumptions rely heavily on data generated during Phase I of this study. Detailed technical analyses were not conducted to support this analysis. A quantifiable reliability analysis should be conducted during Phase III based on more thorough technical data.



SFPUC FACILITIES RELIABILITY PROGRAM

FIGURE 1

OVERVIEW OF BASELINE RELIABILITY ASSESSMENT

This TM provides background information and key assumptions required for a characterization of baseline reliability. The assumptions are presented in the following order.

Section 2.1	Subsystems and Facilities
Section 2.2	Selected Hazard Events
Section 2.3	Facilities Vulnerability
Section 2.4	Demand Assumptions
Section 2.5	Repair Times
Section 2.6	Supply Availability
Section 2.7	Summary of Assumptions Used for Phase II
Appendix	Phase I Repair Times for Complete Restoration

2.1 Subsystems and Facilities

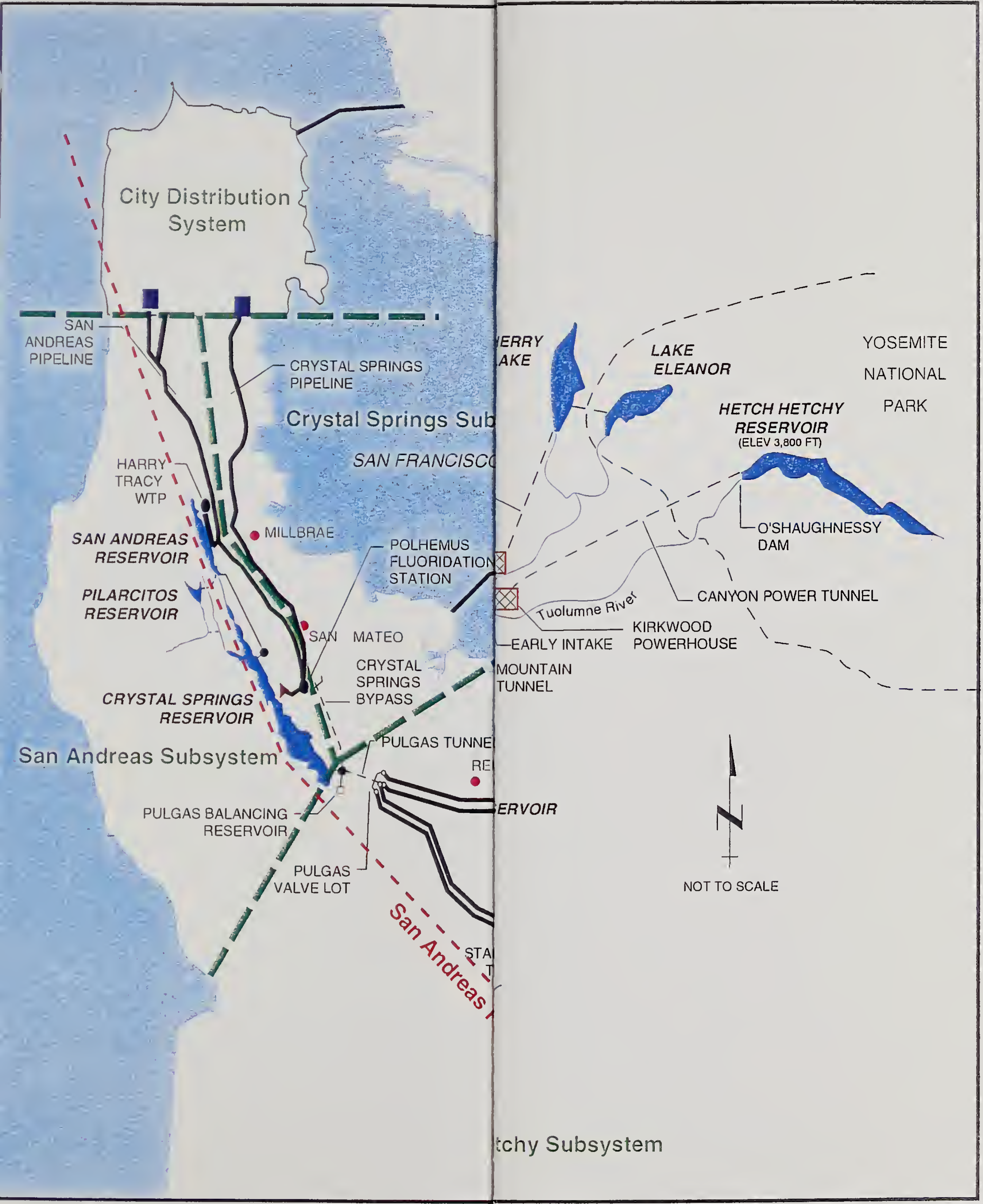
The SFPUC system was disaggregated into six operating subsystems for purposes of evaluating baseline reliability. The grouping of these subsystems reflects primary supply sources as well as the ability to operate somewhat independently in delivering water to customers. The six subsystems are shown graphically in Figure 2: Hetch Hetchy, Sunol Valley, South Bay, Crystal Springs (eastern Peninsula), San Andreas (western Peninsula), and the City Distribution Division (CDD) system. Although the South Bay, San Andreas, and Crystal Springs subsystems include the SFPUC wholesale customers represented by BAWUA, the reliability issues of the individual SFPUC customer's systems are not considered a part of this Phase II effort.

These subsystems and associated facilities are described below. Critical facilities were identified during Phase I and augmented in Phase II. The operational roles of these critical facilities were reviewed in Phase II to determine the linkage of facilities currently providing a flow of water through the system (see appendix in TM No.3). If any of these facilities or groups of facilities were to fail, a determination was made for the baseline reliability characterization (presented in TM No. 3) as to the ability of other facilities to provide some level of service. Testing the importance of these critical facilities to the system is an essential part of Phase III.

The baseline reliability assessment considered all of the critical facilities, understanding the series connectivity role that particular facilities play. During the baseline reliability characterization, additional information (hazards, demand assumptions, repair times, and other assumptions described in this TM No.2) was applied to estimate how the system could respond from a regional perspective under several hazard scenarios.

The resulting baseline reliability characterization (presented in TM No. 3) provides a more in-depth understanding of how the existing system facilities are linked operationally and with a regional perspective. This characterization process identified weak links in the system, those facilities which are vulnerable to selected catastrophic events without an ability to provide some level of service over specific time frames. Results frame the scope of work for Phase III studies and capital improvements.

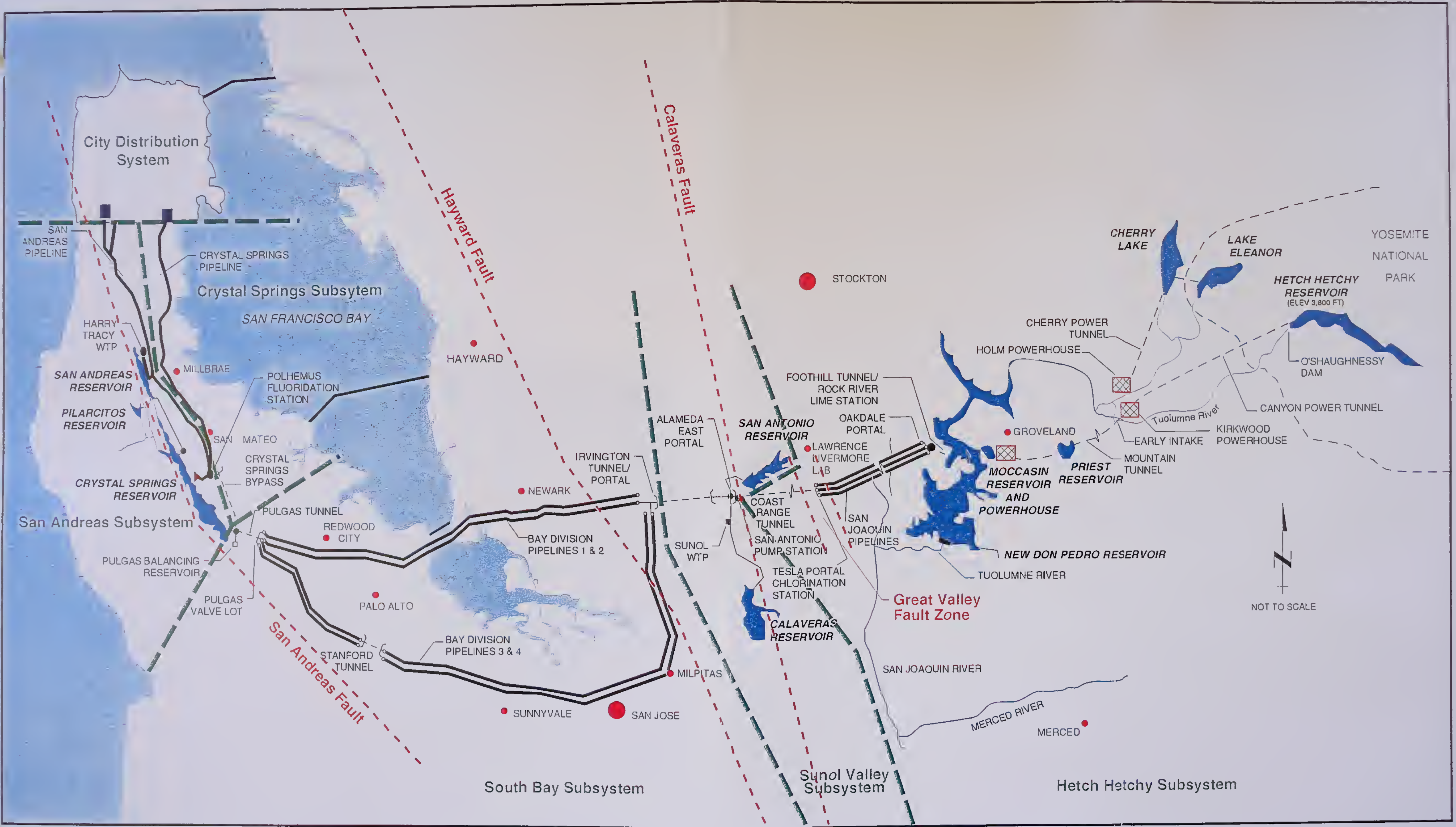
Based on the identification of the system's ability or lack of ability to work around failed facilities, and the baseline reliability response scenarios, several critical facilities were added to the Phase I list. The resulting Phase II critical facilities are listed in a series of tables, by



SFPUC FACILITIES RELIABILITY PROGRAM

FIGURE 2

OVERVIEW OF SUBSYSTEMS



SFPUC FACILITIES RELIABILITY PROGRAM

FIGURE 2

OVERVIEW OF SUBSYSTEMS

SFPUC 1065243 4-99 IW

subsystem, titled Table 1, below. These facilities were considered critical to the system because of their ability to provide operational flexibility and redundancy.

Hetch Hetchy – The Hetch Hetchy subsystem is defined as that region of the water and power system from Hetch Hetchy Project reservoirs to the Alameda East Portal for the water system, and to the City of Newark for the power transmission system. The subsystem water facilities are primarily in series, i.e., linear and without much redundancy; the Cherry-Eleanor system and Hetch Hetchy system are in parallel. Most facilities range in age from 30 to 75 years old. Critical facilities of the Hetch Hetchy subsystem include the following facilities listed from east to west.

Table 1

Hetch Hetchy Subsystem
Critical Facilities

O'Shaughnessy Dam
Hetch Hetchy Reservoir
Canyon Power Tunnel
Lake Eleanor Dam / Reservoir
Early Intake / Bypass
Cherry Dam System
Cherry Valve House
Holm Powerhouse / Penstock
Kirkwood Powerhouse / Penstock
Mountain Tunnel
Priest Dam, Reservoir, Outlet & Tunnel
Moccasin Dam / Reservoir / Pipeline
Moccasin Powerhouse/Penstock/Switchyard
Foothill Tunnel / Oakdale Portal
Red Mountain Bar Siphon
Rock River Lime Plant
San Joaquin Pipelines 1, 2, & 3
California Aqueduct Crossing
Tesla Portal Chlorination Station
Tesla Portal and Coast Range Tunnel

Sunol Valley - The Sunol Valley subsystem is defined as the area between the Alameda East Portal and the West Portal of the Irvington Tunnel. The primary functions of the Sunol Valley facilities are storage and treatment of Calaveras and San Antonio reservoir supplies as well as conveyance of the watershed and Hetch Hetchy supplies to the SFPUC service area. San Antonio Reservoir can also store Hetch Hetchy water and the Sunol Valley WTP can provide treatment to a blend of Hetch Hetchy water. Because of Sunol Valley's proximity to the Calaveras and Hayward faults, the facilities included in this subsystem were considered especially vulnerable to a catastrophic seismic event. The critical facilities of the Sunol Valley subsystem include the following.

Sunol Valley Subsystem
Critical Facilities

Calaveras Dam
San Antonio Pump Station
(San Antonio) Turner Dam
Calaveras Pipeline
Sunol Valley WTP and Associated Pipelines
Alameda (Creek) Siphons
Irvington Tunnel and West Portal

South Bay – The South Bay subsystem receives water from the Sunol Valley subsystem (Hetch Hetchy and Sunol supplies) and is characterized as the transmission subsystem serving the heavily populated southern San Francisco Bay (Bay) customers of the SFPUC delivery system. This subsystem includes the facilities and service between the Irvington Tunnel west portal (on the east side of the Bay) and the Pulgas Tunnel (on the west side of the Bay which includes the Temple and weir). The four Bay Division Pipelines (BDPL) of this subsystem are the principal transmission facilities serving the South Bay and Peninsula SFPUC customers. Portions of the BDPLs No. 1 and 2 are over 70 years old, built above ground on wooden trestles located in Bay marshlands, and have suffered stress from the Loma Prieta earthquake of 1989. The BDPLs are generally considered the most vulnerable section of the SFPUC system, particularly at the west portal of the Irvington Tunnel and at the multiple Hayward Fault crossings. The critical facilities of the South Bay subsystem, from upstream to downstream, include the following.

South Bay Subsystem
Critical Facilities

Bay Division Pipelines 1 & 2
Bay Division Pipelines 3 & 4
Palo Alto Pipeline
Stanford Tunnel
Pulgas Tunnel and Valve Lot
Crystal Springs Balancing Reservoir
Pulgas Pump Station

Crystal Springs (eastern Peninsula) - the Crystal Springs subsystem is characterized as the transmission system that serves customers on the east side of the Peninsula and City. This subsystem is defined as that region of the SFPUC system from the outlet of the Pulgas Tunnel to University Mound Reservoir in the City. From the Crystal Springs Bypass, Hetch Hetchy and/or Sunol Valley treated supplies flow by gravity the length of the Peninsula to the lower elevations of the City system. The critical facilities of the Crystal Springs subsystem, from upstream to downstream, include the following.

Crystal Springs Subsystem
Critical Facilities

- Crystal Springs Bypass Pipeline/Tunnel
- Crystal Springs Pipeline No. 3
- Crystal Springs Pipeline No. 2
- University Mound Feeder Mains*
- University Mound Reservoir*

* These facilities are located in the City subsystem and provide a joint function with the Crystal Springs and San Andreas subsystems, as described further in TM No. 3.

San Andreas (western Peninsula) - The San Andreas subsystem is characterized as the water supply, treatment, and transmission systems that serve the west side of the Peninsula and City systems. This subsystem is defined as that region of the SFPUC system from the lower Crystal Springs Reservoir (raw water) to Sunset Reservoir (treated water) in the City. Crystal Springs and San Andreas reservoirs serve as the primary water supply, via the Harry Tracy WTP, to Daly City, Millbrae, California Water Service systems, North Coast County Water District, SanBruno, Westborough, South San Francisco, and westside City retail customers. Water from Pilarcitos Reservoir supplies the Coastside County Water District and can also be conveyed to San Andreas and Crystal Springs reservoirs. These Peninsula reservoirs are the only SFPUC water supplies west of the Irvington Tunnel. These reservoirs would serve as the primary water supply to the SFPUC system should the Irvington Tunnel experience a major failure that isolates the Hetch Hetchy and Sunol Valley supplies from BAWUA and City customers. The critical facilities of the San Andreas subsystem include the following.

San Andreas Subsystem
Critical Facilities

- Lower Crystal Springs Dam
- Crystal Springs Reservoir
- Crystal Springs Pump Station
- Pilarcitos Dam, Reservoir, & Tunnel
- Crystal Springs-San Andreas Pipeline
- San Andreas Dam / Reservoir
- Harry Tracy WTP
- Capuchino Valve Lot
- San Pedro Valve Lot
- Various Valve Lots
- San Andreas Pipeline
- Sunset Supply Line
- Hillsborough Tunnel
- Baden Pump Station and Valve Lot
- Sunset Reservoir Feeder Mains*
- Sunset Reservoir*

* These facilities are located in the City subsystem and provide a joint function with the Crystal Springs and San Andreas subsystems, as described further in TM No. 3.

City Distribution - The City Distribution subsystem is characterized as the treated water storage and distribution system serving the City of San Francisco. This subsystem is actually divided into two supply systems with a cross town pipeline connection.

- **West Side**: the higher elevation pressure zones are served primarily from Sunset Reservoir on the west side of the City, and
- **East Side**: the lower elevation pressure zones served from University Mound Reservoir on the east side of the City.

The City's distribution system includes reservoirs, storage tanks, pump stations, and distribution system pipelines. Although parts of the City system date back to the 1850s and 1860s, in general it has been a very reliable system. This reliability may be deceptive however, in that much of the system post-dates 1906, and has seen only one significant earthquake since then – the 1989 Loma Prieta event, which did not cause particularly strong shaking in the City or much of the Peninsula. In addition, key distribution system facilities serving the west and north areas of the City pass through liquefaction zones and there is only one limited "cross town" connection between the east and west systems. Critical facilities of the City Distribution subsystem include the following.

**City Distribution Subsystem
Critical Facilities**

Eastside	University Mound Feeder Main*
	University Mound Reservoir*
	Alemany Pump Station
	Cross Town Pipeline
	Bay Bridge Pump Station
	College Hill Reservoir and Feeder Mains
	McLaren Pump Station and Tanks
Westside	Sunset Reservoir Feeder Main*
	Sunset Reservoir *
	Lake Merced Pump Station
	Sutro Reservoir / Feeder Mains
	Summit Reservoir / Feeder Mains
	Merced Manor Reservoir
	Central Pump Station
	Stanford Heights Reservoir and Mains
	Potrero Heights Pump Station
Both	Numerous Distribution Pipelines
	Hydropneumatic and All Other Pump Stations

* These facilities are located in the City subsystem and provide a joint function with the Crystal Springs and San Andreas subsystems, as described further in TM No. 3.

2.2 Hazard Events

Phase I identified types of hazards that could impact the SFPUC system. For Phase II, TM No.1- Hazard Events and Mapping, provided additional information on hazards, particularly earthquake hazards, that could significantly impact the ability of the system to deliver water following an event. These hazards are summarized in the following paragraphs to provide prospective of the exposure of the SFPUC system. In addition, hazards selected for the baseline reliability characterization are indicated.

Earthquake Scenarios - Major faults that cross or are located near SFPUC facilities include the San Andreas fault, Hayward fault, Calaveras fault, Greenville fault, and Great Valley fault zone. As indicated in TM No. 1, these faults have been characterized as having a high potential for occurrence and resulting in a large magnitude events capable of causing strong ground shaking and potential damage. The SFPUC system has performed very well, historically, in response to seismic events, including 1906 (magnitude (Mw)8.3) and 1989 (Mw6.9) events on the San Andreas fault, 1933 and 1937 events on the Hayward fault, and the 1984 (Mw6.2) event on the Calaveras fault.

The magnitude of the anticipated seismic event, the proximity of a fault to SFPUC distribution system facilities, and the availability of other supply sources are key factors in defining the importance of the earthquake hazard as to the reliability of the system meeting water demands. As presented in the maps of TM No. 1, all subsystems can potentially be impacted by an earthquake event. For the analysis of baseline reliability, four earthquake events which pose the greatest concern to the SFPUC system were selected. These hazards are of primary concern because they represent catastrophic regional impacts to the system.

Table 2
Earthquake Hazard Events for Baseline Reliability Assessment

Mw 7.1*	Hayward Fault
Mw 6.8	Calaveras Fault
Mw 7.9	San Andreas Fault
Mw 6.7	Great Valley Fault Zone

* Mw = magnitude

Impacts associated with other earthquake events and other hazards may have more isolated effects on system facilities and supplies versus regional effects, and or the impacts are addressed within one of these earthquake scenarios. Earthquake events can result in ground shaking, fault rupture, liquefaction, landslides, power failure, and fire impacts; these associated impacts are taken into account in assessing the baseline reliability of the SFPUC system under these four scenarios.

Landslides – Because of the unstable geology of the East Bay, South Bay and Peninsula hillsides, landslides pose a hazard to SFPUC pipeline facilities, in conjunction with, or independent of seismic events. This hazard demonstrated itself in the winter of 1998 when the Crystal Springs Bypass Pipeline, a critical link for the San Andreas and City subsystems, was threatened by a severe landslide. The subsystems most likely to be impacted by landslides include South Bay, Crystal Springs, and San Andreas. Detailed investigations of landslide hazards are site specific and data intensive and therefore are not included as a hazard to be analyzed for baseline reliability.

Flood Scenarios – Floods pose a hazard to the SFPUC system in two ways:

- if facilities are within flood prone areas, or
- when high stormwater inflows result in high levels of turbidity (due primarily to the erosion of soils and the resuspension of sediment).

Historically, flooding of facilities and events associated with high stormwater inflows has not significantly threatened the ability of the SFPUC system to deliver water due to the isolated nature of the impact and because above-ground facilities are generally not built in flood prone areas. Turbidity events associated with high stormwater inflows, however, have reduced the availability of the impacted supply source, but for a relatively short duration during which time other supply sources were used. The subsystems most likely to be impacted by water quality related events associated with flooding include Hetch Hetchy, Sunol Valley, and San Andreas. Because water quality events from high stormwater inflow are regionally isolated events, can be somewhat predicted, and the system operations can be adjusted to use a different supply during these times, this event does not result in impacts to the system which are not already addressed under the selected seismic events.

Fire Scenarios – The primary fire scenarios of concern for the SFPUC system are wildland fires and urban fires. Fires pose a threat not only to individual above-ground facilities, but also to the quality of source waters. Wildland fires in the watershed, followed by a rainfall event, can result in major turbidity incidents, affecting the availability of source waters due to water quality conditions. This is of particular concern for the reliability of the Hetch Hetchy watershed because of its filtration avoidance status. The Alameda and Peninsula watersheds have treatment plants designed to respond to turbidity spikes, but the ability of the Sunol Valley WTP to treat turbid Hetch Hetchy waters is limited to its capacity. As with flooding events, turbidity events reduce the availability of the impacted supply source, but for a relatively short duration during which time other supply sources can be used. The subsystems most likely to be impacted by wildfires include Hetch Hetchy, Sunol Valley, and San Andreas. Because water quality events from fires can be somewhat predicted due to time between a fire and rainfall, this event does not result in impacts to the system which are not already addressed under the selected seismic events

Large urban fires, particularly resulting from earthquakes, pose a considerable response challenge for the SFPUC system. The 1906 earthquake resulted in 28,000 buildings destroyed by fire, and the 1989 Loma Prieta earthquake also resulted in conflagrations within the City. This response challenge is exacerbated by the fact the local storage capacity of many suburban customers is limited, and therefore many agencies rely heavily on the SFPUC system to provide a sustainable peak supply for fire fighting. The subsystems most likely to be impacted by urban fires include South Bay, Crystal Springs, San Andreas, and City Distribution. For the baseline reliability assessment, impacts related to fires following earthquakes will be considered as an impact associated with the selected earthquake hazards.

Age, Wear, and Tear, and Vandalism and Sabotage – Age, wear, and tear relate to the remaining useful life of a facility. The age and condition is typically considered an "additional vulnerability" of a particular facility. Wear and tear was used in Phase I to describe a condition where age, special conditions, or obsolescence effected the ability to maintain a facility. Special conditions included soil corrosivity and obsolescence described conditions such that parts or supplies were difficult or impossible to obtain. Age, wear, and tear, as well as materials of construction will be considered during the individual structural and geotechnical assessments of facilities during Phase III.

Sabotage is related to the accessibility and attractiveness of SFPUC facilities to vandals. A vandalism/sabotage event is also considered an additional vulnerability of a particular facility because of the public accessibility to so much of the system. All subsystems can potentially be impacted by sabotage in isolated events, and are therefore not recommended to be addressed as part of the baseline reliability analysis.

2.3 Vulnerability of Facilities

The vulnerability of facilities was generally described in Phase I by the number and degree of potential risks to the facility, its most likely mode of failure, and the likelihood that the facility will fail. The purpose of establishing assumptions of the vulnerability of the critical facilities was to consider each facilities' likelihood to complete its function for delivering water to SFPUC customers following a given event.

For Phase II, earthquake hazard mapping was performed and the SFPUC facilities overlaid to provide more specificity on which facilities may be impacted by each earthquake event. Table 3 presents the degree of risk and associated earthquake hazard. The degree of risk associated with an earthquake mode of failure was determined in Phase I and is presented here for each critical facility, as an estimate, ranked high, medium or low. For critical facilities added during Phase II, the degree of risk was not available, instead, a review of the PGAs associated with the facilities were used to determine the degree of risk associated with earthquake hazard. This assessment of degree of risk should be revisited during Phase III utilizing a more thorough analysis of the vulnerability and probability of failure of each critical facility.

The earthquake hazard with the greatest potential for impacting each facility is also provided in Table 3. The selected hazards include a large magnitude earthquake on the San Andreas fault, Hayward fault, Calaveras fault, and Great Valley fault zone. The hazard with the highest range of PGA for each critical facility is indicated in Table 3. Further information on the PGA ranges associated with each hazard can be found in TM No.1.

In summary, for the baseline reliability characterization three factors were taken into account in determining if a facility would fail: the Phase I assumptions of risk, the Phase II earthquake hazards, and the Phase II identification of facilities with a PGA of 0.5g or greater. However, without additional detailed assessments of each event on each critical facility, it is not specifically known to what extent damage may occur throughout the system. Therefore, this information does not necessarily reflect the full extent of potential damage. A probability of failure analysis is recommended for Phase III. The probability of failure represents the chance that a facility will fail to perform its assigned function (pumping, treatment, transmission, etc.)

given a hazard event. Fragility curves could provide a more rigorous set of assumptions than that used here for characterizing baseline reliability.

Table 3

Hetch Hetchy Subsystem
Vulnerability of Critical Facilities

Hetch Hetchy Subsystem Critical Facility	Hazard (PGA range)	Phase I Degree of Risk
O'Shaughnessy Dam	Great Valley (.0-.1)	Low
Hetch Hetchy Reservoir	Great Valley(.0-.1)	Low
Canyon Power Tunnel	Great Valley (.0-.1)	Low
Lake Eleanor Dam/Reservoir	Great Valley (.0-.1)	Low
Early Intake/Bypass	Great Valley (.0-.1)	Low
Cherry Dam System	Great Valley (.0-.1)	Low
Cherry Valve House	Great Valley (.0-.1)	Low
Holm Powerhouse/Penstock	Great Valley (.0-.1)	Low
Kirkwood Powerhouse/Penstock	Great Valley (.0-.1)	Low
Mountain Tunnel	Great Valley (.0-.1)	Low
Priest Dam, Reservoir, Outlet, & Tunnel	Great Valley (.0-.1)	Low
Moccasin Dam/Reservoir/Pipeline	Great Valley (.0-.1)	Low
Moccasin Powerhouse/Penstock/Switchyard	Great Valley (.0-.1)	Low
Foothill Tunnel	Great Valley (.0-.1)	Low
Red Mountain Bar Siphon	Great Valley (.0-.1)	Low
Rock River Lime Plant	Great Valley (.1-.2)	Medium
Oakdale Portal	Great Valley (.1-.2)	Medium
San Joaquin Pipelines 1,2 & 3	Great Valley (.1-.5)	High
California Aqueduct Crossing	Great Valley (.4-.5)	High
Tesla Portal Chlorination Station	Great Valley (.4-.5)	High
Tesla Portal and Coast Range Tunnel	Great Valley (.1-.5) Calaveras (.1-.7)	High

Sunol Valley Subsystem
Vulnerability of Critical Facilities

Sunol Valley Subsystem Critical Facility	Hazard (PGA range)	Phase I Degree of Risk
Calaveras Dam	Calaveras (.2-.7) Hayward (.2-.6)	High
San Antonio Pump Station	Calaveras (.6-.7) Hayward (.5-.6)	High
(San Antonio) Turner Dam	Calaveras (.6-.7) Hayward (.5-.6)	Medium
Calaveras Pipeline	Calaveras (.6-.7) Hayward (.5-.6)	Medium
Sunol Valley WTP and Associated Pipelines	Calaveras (.6-.7) Hayward (.5-.6)	High
Alameda Creek Siphons	Calaveras (.2-.7) Hayward (.2-.6)	High
Irvington Tunnel and West Portal	Calaveras (.5-.7) Hayward (.6-.7) San Andreas (.2-.3)	High

South Bay Subsystem
Vulnerability of Critical Facilities

South Bay Subsystem Critical Facility	Hazard (PGA range)	Phase I Degree of Risk
Bay Division Pipelines 1 & 2	Calaveras (.1-.6) Hayward (.1-.7) San Andreas (.2-.9)	High
Bay Division Pipelines 3 & 4	Calaveras (.1-.6) Hayward (.1-.7) San Andreas (.2-.9)	High
Palo Alto Pipeline	San Andreas (.4-.7)	Low
Stanford Tunnel	San Andreas (.6-.7)	Low
Pulgas Tunnel & Valve Lot	San Andreas (.5-.9)	Medium
Crystal Springs Balancing Reservoir/Pulgas Pump Station	San Andreas (.5-.6)	High

Crystal Springs Subsystem
Vulnerability of Critical Facilities

Crystal Springs Subsystem Critical Facility	Hazard (PGA range)	Phase I Degree of Risk
Crystal Springs Bypass Pipeline/Tunnel	Hayward (.1-.3) San Andreas (.5-.9)	High
Crystal Springs Pipeline No. 3	Hayward (.1-.3) San Andreas (.5-.7)	Low
Crystal Springs Pipeline No. 2	Hayward (.2-.3) San Andreas (.4-.7)	Medium
University Mound Feeder Mains	Hayward (.2-.3) San Andreas (.4-.5)	High
University Mound Reservoir	Hayward (.2-.3) San Andreas (.4-.5)	Medium

San Andreas Distribution Subsystem Vulnerability of Critical Facilities

San Andreas Subsystem Critical Facility	Hazard (PGA range)	Phase I Degree of Risk
Lower Crystal Springs Dam	Hayward (.1-.3) San Andreas (.5-.7)	High
Crystal Springs Reservoir	Hayward (.1-.2) San Andreas (.5-.6)	High
Crystal Springs Pump Station	Hayward (.1-.3) San Andreas (.5-.7)	High
Pilarcitos Dam, Reservoir, & Tunnel	San Andreas (.5-.6)	High
Crystal Springs-San Andreas Pipeline	Hayward (.1-.3) San Andreas (.5-.7)	Low
San Andreas Dam/Reservoir	Hayward (.1-.3) San Andreas (.5-.6)	High
Harry Tracy WTP	Hayward (.1-.3) San Andreas (.5-.7)	Medium
Capuchino Valve Lot	Hayward (.2-.3) San Andreas (.5-.7)	Low
San Pedro Valve Lot	Hayward (.2-.3) San Andreas (.5-.7)	Medium
San Andreas Pipeline No. 2	Hayward (.2-.3) San Andreas (.5-.7)	Medium
Sunset Supply Line	Hayward (.2-.3) San Andreas (.5-.7)	Medium
Hillsborough Tunnel	Hayward (.2-.3) San Andreas (.5-.7)	Low
Baden Pump Station and Valve Lot	Hayward (.2-.3) San Andreas (.5-.7)	Medium
Sunset Reservoir Feeder Mains	Hayward (.2-.3) San Andreas (.5-.7)	Medium
Sunset Reservoir	Hayward (.2-.3) San Andreas (.6-.7)	Low

City Distribution Subsystem
Vulnerability of Critical Facilities

City Distribution System Critical Facility	Hazard (PGA range)	Phase I Degree of Risk
Alemany Pump Station	Hayward (.2-.3) San Andreas (.4-.5)	Low
Cross Town Pipeline	Hayward (.2-.3) San Andreas (.4-.8)	Low
Bay Bridge Pump Station	Hayward (.2-.4) San Andreas (.4-.6)	High
College Hill Reservoir and Feeder Mains	Hayward (.2-.3) San Andreas (.4-.8)	Medium
McLaren Pump Station and Tanks	Hayward (.2-.3) San Andreas (.7-.8)	Medium
Lake Merced Pump Station	Hayward (.2-.3) San Andreas (.5-.6)	High
Sutro Reservoir and Feeder Mains	Hayward (.2-.3) San Andreas (.4-.8)	Medium
Summit Reservoir and Feeder Mains	Hayward (.2-.3) San Andreas (.4-.8)	Low
Merced Manor Reservoir	Hayward (.2-.3) San Andreas (.5-.7)	High
Central Pump Station	Hayward (.2-.3) San Andreas (.5-.7)	High
Stanford Heights Feeder Mains	Hayward (.2-.3) San Andreas (.6-.8)	Low
Stanford Heights Reservoir	Hayward (.2-.3) San Andreas (.6-.8)	Medium
Potrero Heights Pump Station	Hayward (.2-.4) San Andreas (.4-.6)	High

2.4 Demand Assumptions

The anticipated water demands of the SFPUC system following a catastrophic event were conceptually identified for consideration in the baseline reliability analysis. These "system demand response" assumptions were based on a percentage of average day demand (ADD) of each subsystem following an event, at given intervals after the event. It is recommended that these demand responses be confirmed for Phase III based on SFPUC customer input.

2.4.1 Average Day Demands

The ADD assumed for each subsystem (which became the basis for estimating demand response assumptions) were based on the average day SFPUC system demand of 260 mgd and are summarized in Table 4. The Hetch Hetchy demands include service to Groveland and Lawrence Livermore Laboratories. The Sunol Valley demands include service to the community of Sunol. All subsystem demands are approximate including the distribution of CDD demands between the east and west systems.

Table 4
SFPUC System
Average Day Demands by Subsystem

Subsystem	Assumed ADD Within Subsystem
Hetch Hetchy	2 mgd
Sunol Valley	1 mgd
South Bay	107 mgd
Crystal Springs	40 mgd
San Andreas	30 mgd
City Distribution	West – 30 mgd East – 50 mgd
Total	**260 mgd**

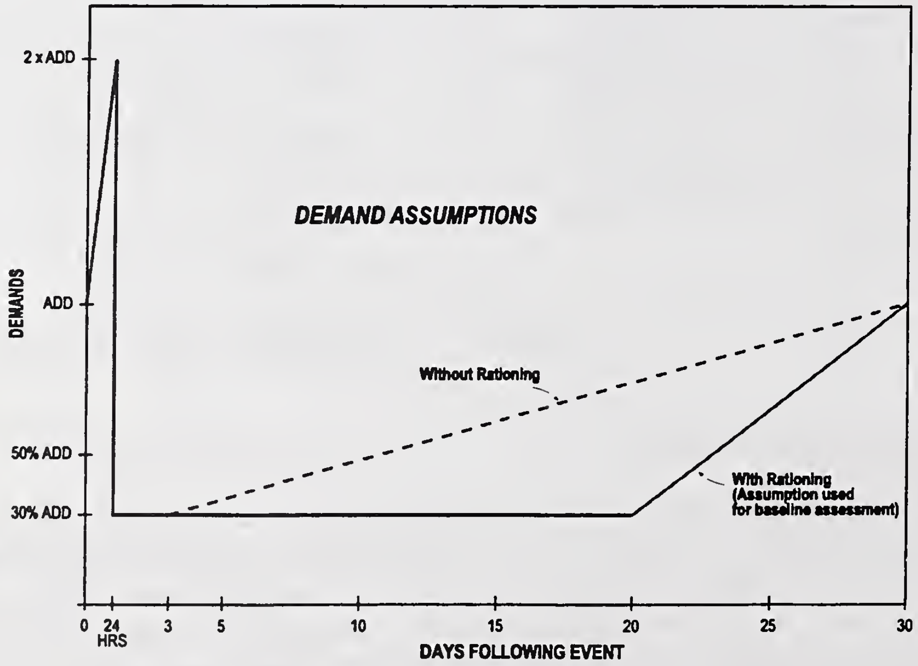
2.4.2 Demand Response Assumptions

The baseline reliability analysis utilized different demand assumptions over different response periods, as summarized below, in evaluating the system's ability to respond to post-earthquake events. It should be noted that these demand assumptions are rough estimates based on analyses of other water purveyors. A more thorough analysis of the condition of the service area building stock and fire fighting capabilities is recommended to be conducted by each SFPUC customer to refine these demand response estimates. In addition, power outage assumptions from PG&E, repair time estimates, and mutual aid agreement assumptions are required during Phase III to confirm these demand assumptions and to provide an estimate of system losses from pipe breaks.

The greatest demands placed on the system are anticipated to occur within the first 24 hours following an event, along with the startup of emergency response activities. The 24 hour demand represents the essential distribution system needs (about 30 percent of a system's ADD for the regional system and about 50 percent for the CDD) plus the fire following earthquake demands. The total of which has been assumed for this analysis to be equivalent to about two times the ADD. This 24 hour demand does not include water supply lost to pipe breaks. This critical demand assumption was based on other purveyor's analyses and represents a rough estimate for the overall SFPUC system.

After 24 hours as the fire fighting demands decrease, distribution system demands will remain low due to the public awareness of a catastrophic event having taken place. Because of this public awareness and the assumed poor condition of the impacted distribution systems, it is assumed that in the areas most impacted, the demands will remain at a low level reflecting only essential needs. Essential needs between 24 hours and three days may vary from 30 percent in the suburban service area to 50 percent within the CDD based on the lowest level of indoor water use plus limited nonresidential uses. This assumed demand response is presented in Figure 3.

These minimum distribution system demands will slowly increase as residents and businesses begin to recover from the effects of the event. Demands within the outlying areas will return to normal faster than in the impacted areas. Depending on the extent of damage to industrial facilities and the water distribution systems, industrial and commercial demands may recover more rapidly than residential demands due to the individual company's need to minimize economic losses. It is assumed that after three days, distribution system demands in impacted



SFPUC FACILITIES RELIABILITY PROGRAM

FIGURE 3

DEMAND ASSUMPTIONS FOR IMPACTED AREAS

areas will increase from 30 percent of ADD to 50 percent of ADD within 10 days; and to 100 percent ADD within 30 days. If the event is followed by warm weather, the demands at 30 days may approach maximum day demand (MDD) levels. Demands in the outlying areas are assumed to be at 50 percent of ADD within three days increasing to 100 percent ADD within 10 days.

However, considering the consequences of catastrophic events and the anticipated damage to both the SFPUC system and the customer's distribution systems, it is assumed that an aggressive emergency rationing program is imposed on all wholesale and retail customers of the SFPUC system. The above distribution system demands may, therefore, be reduced by maintaining the essential levels for a greater period of time, as presented in Figure 3 and Table 5. The demand assumptions reflecting rationing effects were used for this baseline reliability characterization.

Table 5
System Demand Assumptions (with Rationing)
Following a Catastrophic Event

Time Frame	Demand Assumption
Prior to Event	Average Day Demand (ADD)
0 to 24 hours following an event – for the impacted subsystems	2 times ADD for Regional System; Slightly higher for CDD
0 to 24 hours following an event – for the subsystem outside the impacted subsystems	ADD
24 hours to 20 days – for the impacted subsystems	30 percent of ADD for Regional System; 50 percent of ADD for CDD
24 hours to 20 days – for the subsystem outside the impacted subsystems	50 percent of ADD
20 days to 30 days – for the impacted subsystems	Gradually up to ADD
20 days to 30 days – for the subsystem outside the impacted subsystems	ADD
After 30 days – all subsystems	ADD to maximum day demand

These demand assumptions presented in Table 5 were used to review the baseline reliability of the SFPUC system, the capabilities of the existing treatment and transmission systems, and the sustainability of the local watershed supplies to deliver those supplies following an event. During Phase III, demand assumptions may be compared with "targeted service objectives" which are described in more detail in TM No.4.

2.5 Repair Times

The restoration capabilities of the SFPUC system immediately following a catastrophic event were generally estimated in Phase I as the length of time after an event to restore normal operations for individual facilities of the SFPUC system. The difficulty in using these repair times for the baseline reliability analysis is that, realistically, temporary repairs of critical facilities may take place following an event to allow for some amount of water through the system. The more permanent restoration times from Phase I are provided in the appendix.

It is recommend that the repair times be refined in the Phase III analysis to reflect temporary solutions specific to the individual facilities and potential events. This information will be useful in providing a more thorough analysis of the recovery time of the system after an event, and in determining if a capital improvement is needed versus a response solution (e.g., repair, stockpiled materials, mutual aid).

In response to catastrophic events, it is likely that temporary restoration of facilities could be achieved to provide at least partial service until such time as the damaged facility could be restored to normal operation. As a result, temporary repair times were identified by type of facility, in order to provide alternative operational responses to the impacted system facilities, and are provided in Table 6. The system's ability to meet these repair times depends on the extent of regional damage, availability of in-house or mutual aid staff to respond, availability of repair materials, accessibility to the facility locations, etc. These estimates are very optimistic and are based on the assumption that crews are available to work full time on each repair.

Table 6
Temporary Restoration Times
(Days Following Event)

Facility Type	Time to Complete Temporary Repairs(1)
Pump Stations	2 days (2)
Water Treatment Plants	3 to 6 days (2)
Storage tanks	25 to 30 days
Tunnels	30 to 60 days
Pipelines	Up to 40 days

(1) Temporary restoration capabilities are conceptual estimates based on the experiences and judgement of other utilities. These temporary restoration capabilities will be more rigorously defined for the SFPUC system in Phase III. These are base on single facilities failure; multiple facilities failure will likely lead to longer repair times than those indicated here.

(2) Assumes only mechanical repairs required – if structural damage occurs, time required is longer.

Treatment plant restoration utilizing temporary fixes could possibly be completed in less than six days depending on what treatment equipment or facilities require repair. It is possible that water quality requirements could be relaxed for a short period of time to meet the demand requirements of the system. During a catastrophic event, meeting water supply needs will likely be more important than meeting potable drinking water standards. However, if a nonpotable supply is introduced into the SFPUC system, the State Department of Health Services will require disinfection and flushing of both SFPUC and wholesale customer facilities prior to the lifting of boil water notifications. This requirement will result in temporary outages of conveyance facilities resulting in a very significant affect on meeting increasing demands following an event if no other facilities are available during this time.

The temporary repair times indicated above were utilized for the baseline reliability assessment where it appeared that a temporary repair could be made. It was assumed that most SFPUC system facilities could be at least partially operational within 30 days after an event with a few noted exceptions. In the case when a tunnel collapse is included, normal capacity would be temporarily restored within 30 to 60 days. It will likely take longer than 30 days to provide temporary repairs for more than one of the BDPLs. The resulting repair assumptions are provided in Table 7.

The longest repair times to restore functionally unique facilities to 100 percent capacity are also provided in Table 7. This was achieved by comparing the facility restoration times of all the critical facilities impacted by a similar event and identifying the longest facility restoration period. These conservative repair time estimates provide an indication of the length of time required to bring the system back up to full capacity following an event.

It is these temporary repair time assumptions that the baseline reliability characterization utilized for comparison to the demand assumptions, the availability of “surviving” facilities, and the accessibility to water supplies, as presented in TM No. 3. Again, these temporary repair estimates are very optimistic and are based on the assumption that crews are available to work full time on each repair.

2.6 Supply Availability

The baseline reliability assessment also relied on assumptions regarding the availability and use of existing water supplies. An assumption was made that 65 percent of the total raw water reservoir storage capacity was available at the time of an event, as presented in Table 8. This accounts for unusable storage capacity as well as an event occurring during times of reduced storage (seasonal fluctuations). A more rigorous analysis of the supply fluctuations may be conducted, but it is not anticipated that a differing result will be of significance due to the vulnerability anticipated for the facilities. It is recommended that this assumption of supply availability be utilized during the Phase III analysis.

2.7 Summary of Assumptions Used for Phase II

In order to characterize the baseline reliability for Phase II, the assumptions presented in this TM No. 2 were developed and utilized. As stated above, most of the assumptions lack quantifiable data and information and need to be revisited during the more thorough Phase III reliability analysis. Table 9 presents a summary of the assumptions used and how they should be modified, if necessary, for Phase III.

Table 7
Critical Path Repairs by Hazard Event
(Time Following Event)

Hazard Event	Temporary Repair Assumptions Used in Baseline Reliability Assessment[1]	Time to Complete Permanent Repairs[2]
Great Valley Fault Zone	30 days – Pipelines	3 mo. Foothill Tunnel > 1 yr. O'Shaughnessy Dam 12 mo. Red Mountain Bar Siphon
Calaveras Fault	60 days – Irvington Tunnel 20 days – BDPL#3 30 days – Pipelines	6 to 12 mo. SVWTP 3 to 6 mo. Alameda Creek Siphons 3 to 6 mo. Irvington Tunnel > 1 yr. Calaveras Dam > 1 yr. San Antonio Dam
Hayward Fault	60 days – Irvington Tunnel 20 days – BDPL#3 30 days – Pipelines	6 to 12 mo. BDPLs 1 & 2 6 to 12 mo. BDPLs 3 & 4 3 to 6 mo. Baden PS
San Andreas Fault	20 days – BDPL#3 30 days – Pipelines	> 1 yr. San Andreas Reservoir 6 to 12 mo. BDPLs 1 & 2 6 to 12 mo. BDPLs 3 & 4 3 to 6 mo. Baden PS 1 to 3 mo. Crystal Springs PS 6 to 12 mo. Lake Merced PS

Footnotes:

1. The longest duration temporary repair times for critical facilities are indicated here.
3. The facilities listed are either the most vulnerable to that hazard event, or have the longest duration repair time.

Table 8
SFPUC System
Water Supply Availability

Water Supply Source	Storage Volume (total capacity)	Storage Volume (65 percent)
Hetch Hetchy Reservoir	360,360 acre-feet 117 billion gallons	234,200 acre-feet
Calaveras and San Antonio Reservoirs	96,850 + 50,500 acre feet 48 billion gallons	95,800 acre-feet
Crystal Springs, San Andreas, and Pilarcitos Reservoirs	69,300 + 19,000 + 3,100 acre feet 29 billion gallons	59,400 acre-feet

Table 9
Assumptions Used for Phase II Characterization of Baseline Reliability

1. The list of **Critical Facilities** from Phase I was augmented based on the identification of facilities linkages and the baseline reliability response scenarios. The list of critical facilities should be used in Phase III to focus the conditions assessments and in determining temporary repair times, as discussed below.

2. The selected earthquake **hazard events** encompass impacts associated with other types of hazards and therefore should be utilized for SFPUC facilities assessments and the Phase III reliability analysis. Hazards associated with specific facilities which are not addressed under these catastrophic events, if any, will be identified in the structural and geotechnical assessments to be performed on each critical facility and the results included in the Phase III analysis.

3. Phase II information on impacts from seismic hazards (selected hazards, magnitudes, and PGAs) should be utilized in Phase III and augmented with a more rigorous probability of failure analysis to determine the **vulnerability** of each critical facility.

4. Assumptions regarding how **customer demands** respond following an event were made for a 30 day period and are based on average day demands. The demand response assumptions need confirmation from SFPUC customers. Targeted Service Objectives are needed for Phase III to evaluate alternative levels of reliability against costs. These targeted service objectives may be based on what levels of demands the system is to meet or outages the system is willing to accept.

5. Phase II identified **temporary repair times** for generalized facilities. Phase III will require the determination of temporary repair times specific to each critical facility. Phase I permanent restoration times need to be reassessed based on the new hazards information.

6. The availability of existing **water supplies** was based on 65 percent of the total capacity of the Hetch Hetchy Reservoir and the local reservoirs. This determination of supply availability can be carried into the Phase III analysis.

Appendix

Phase I Repair Times for Complete Restoration

The restoration capabilities assumed in the Phase I study were based on the engineering judgement and experience of SFPUC operations and engineering staff and are shown in Table A. These permanent repair times were based on the length of time after an event to restore normal operations for individual facilities.

Table A
Hetch Hetchy Subsystem
Permanent Repair Times

Critical Facility	Repair Time
O'Shaughnessy Dam	> 1 yr
Canyon Power Tunnel	3 to 30 days
Lake Eleanor	> 1 yr
Early Intake / Cherry Dam System	> 1 yr
Cherry Valve House	3 to 6 mo.
Holm Powerhouse/Penstock	6 to12 mo.
Kirkwood Powerhouse/Penstock	> 1 yr
Mountain Tunnel	1 to 3 mo.
Priest Dam, Reservoir, Outlet & Tunnel	15 to 30 days
Moccasin Creek Dam/Pipeline	> 1 yr
Moccasin Dam/Reservoir	6 to 12 mo.
Moccasin Powerhouse/Penstock	> 1 yr
Moccasin Switchyard	1 to 7 days
Foothill Tunnel	1 to 3 mo.
Red Mountain Bar Siphon	1 to 12 mo.
Rock River Lime Plant	3 to 12 mo.
Oakdale Portal	1 to 12 mo.
San Joaquin Pipelines 1,2 & 3	1 to 12 wks
California Aqueduct Crossing	1 to 3 mo.
Tesla Portal	1 to 12 mo.
Coast Range Tunnel	3 to 6 mo.

Sunol Valley Subsystem
Permanent Repair Times

Critical Facility	Repair Time
Calaveras Dam	> 1 yr.
San Antonio Pump Station	3 to 6 mo.
Turner Dam (San Antonio)	> 1 yr.
Sunol Valley WTP	1 to 12 mo.
Alameda Creek Siphons	3 to 6 mo.
Irvington Tunnel	3 to 6 mo.

South Bay Subsystem
Permanent Repair Times

Critical Facility	Repair Time
Bay Division Pipelines 1 & 2	1 to 12 mo.
Bay Division Pipelines 3 & 4	1 to 12 mo.
Pulgas Tunnel	2 to 3 mo.

Crystal Springs Subsystem
Permanent Repair Times

Critical Facility	Repair Time
Pulgas Balancing Reservoir	1 to 6 mo.
Crystal Springs Bypass Pipeline/Tunnel	15 to 30 days
Crystal Springs Pipeline No. 3 at Hillsborough	3 to 7 days
Crystal Springs Pipelines No. 1 & 2	3 to 6 mo.
University Mound Feeder Mains	15 to 30 days
University Mound Reservoir	3 to 6 mo.

San Andreas Subsystem
Permanent Repair Times

Critical Facility	Repair Time
Lower Crystal Springs Dam	> 1 yr.
Crystal Springs Pump Station	1 to 3 mo.
Pilarcitos Dam, Reservoir, & Tunnel	> 1 yr.
Crystal Springs-San Andreas Pipe	15 to 30 days
San Andreas Reservoir	> 1 yr.
Harry Tracy Water Treatment Plant	> 1 yr.
Capuchino Valve Lot	3 to 6 mo.
Baden Pump Station	3 to 6 mo.
San Pedro Valve Lot	3 to 6 mo.
Sunset Supply Line	3 to 7 days
Lake Merced Pump Station	6 to 12 mo.
Sunset Reservoir Feeder Mains	15 to 30 days
Sunset Reservoir	3 to 6 mo.

City Distribution Subsystem
Permanent Repair Times

Critical Facility	Repair Time
Alemany Pump Station	3 to 6 mo.
Cross Town Pipeline	15 to 30 days
College Hill Feeder Mains	7 to 14 days
College Hill Reservoir	3 to 6 mo.
McLaren Tanks	> 1 yr.
Sutro Reservoir Feeder Mains	7 to 14 days
Sutro Reservoir	3 to 6 mo.
Summit Reservoir Feeder Mains	7 to 14 days
Summit Reservoir	6 to 12 mo.
Merced Manor Reservoir	3 to 6 mo.
Central Pump Station	1 to 3 mo.
Stanford Heights Feeder Mains	7 to 14 days
Stanford Heights Reservoir	6 to 12 mo.

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT: Technical Memorandum No. 3
Baseline Reliability Response

PREPARED BY: The Water Reliability Partnership

DATE: July 23, 1999

Table of Contents

Page

1.0 Introduction 2

2.0 Description of System Operations 3

- 2.1 Regional System 3
- 2.2 City Distribution Division System 5

3.0 Approach to Baseline Reliability 9

- 3.1 Definition of Baseline Reliability 9
- 3.2 TM No. 2 Assumptions 9
- 3.3 Approach 13

4.0 Baseline System Responses 15

- 4.1 San Andreas Fault Event Response 16
  - 4.1.1 Regional System Response to San Andreas Fault Event 16
  - 4.1.2 CDD Response to San Andreas Fault Event 26
- 4.2 Hayward Fault Event Response 31
- 4.3 Calaveras Fault Event Response 38
- 4.4 Great Valley Fault Zone Event Response 45
- 4.5 Baseline Reliability Findings 51
  - 4.5.1 Regional Facilities 51
  - 4.5.2 CDD Facilities 57

APPENDIX

A. Facility Linkages and Function/Operational Relationships

1.0 INTRODUCTION

Technical Memorandum (TM) No. 3 is part of the Task 3 work of the SFPUC Facilities Reliability Program Phase II Regional System Overview. The goal of Task 3 is to establish the baseline reliability of the overall SFPUC system and to identify the weak links, problem areas and impacts on services. A time sequence analysis of how the existing system may respond under selected hazard events is presented. The baseline reliability scenarios are intended to be representative of major seismic events the SFPUC system would need to respond to, given its existing condition and configuration. The findings of this Task 3 work will be the basis for development of the Phase III scope of work, to be documented in TM No. 4.

2.0 DESCRIPTION OF SYSTEM OPERATIONS

2.1 Regional System

Over 2.4 million people in the City and County of San Francisco (City), the Peninsula, and the South and East Bay areas depend in whole or in part on water delivered from the SFPUC system to sustain economic stability, economic growth, and a high quality of life. The SFPUC system supplies virtually all of the water needs of the City and about 60 percent of the water used by the SFPUC's 29 wholesale suburban customers in the Bay Area, many of whom rely entirely upon SFPUC supplies to meet their residential and industrial needs. The SFPUC system develops water supply from two primary sources.

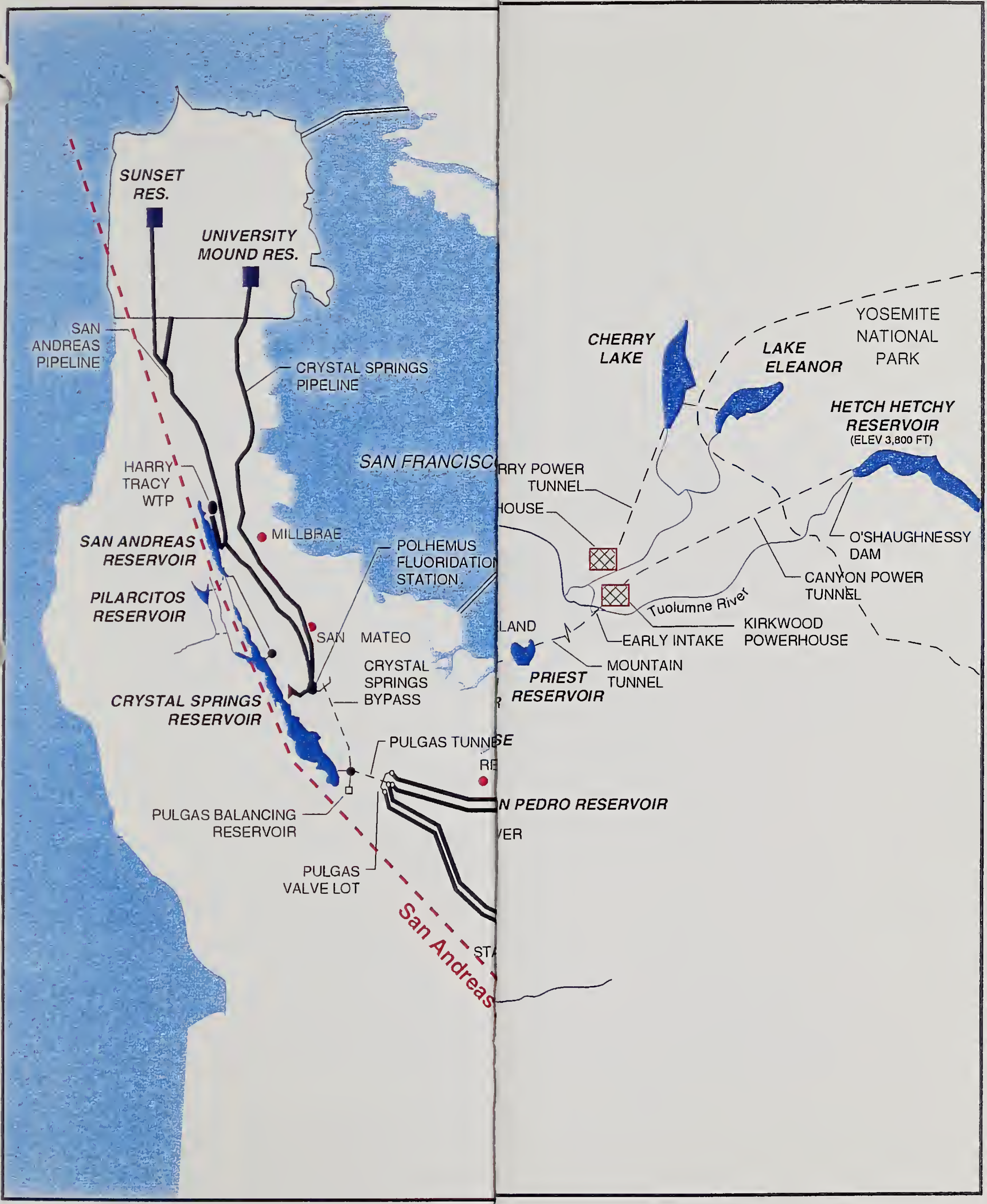
- Hetch Hetchy Water and Power Project which impounds Tuolumne River watershed runoff from the Sierra Nevada range; and
- Local runoff into Bay Area reservoirs from the Coast Range watersheds (in Alameda and Santa Clara Counties) and Peninsula watersheds (in San Mateo County)

In general, the Hetch Hetchy Water and Power Project consists of the reservoirs, hydroelectric power generation and transmission facilities, and water transmission tunnels and pipelines from Hetch Hetchy Valley west to the Alameda East Portal on the west side of the Coast Range Mountains. The local Bay Area water system comprises facilities from Alameda East Portal west, including reservoirs, water treatment plants, and distribution facilities that deliver water to SFPUC wholesale and retail customers up to San Francisco. A schematic of the system is shown in Figure 1.

Hetch Hetchy Water and Power Project. On average, the Hetch Hetchy Water and Power Project provides 83 percent of the total SFPUC system supply. Tuolumne River watershed runoff is impounded in three major reservoirs: Hetch Hetchy, Lake Eleanor, and Lake Lloyd (Cherry Lake). Water flows by gravity through a series of pipeline aqueducts and tunnels from the mountains across the San Joaquin Valley to the Bay Area.

The water from Hetch Hetchy Reservoir is used for municipal and industrial water supply, as well as hydroelectric power generation and downstream releases. Under normal conditions, it is the only reservoir on the Tuolumne River that supplies water directly to the Bay Area.

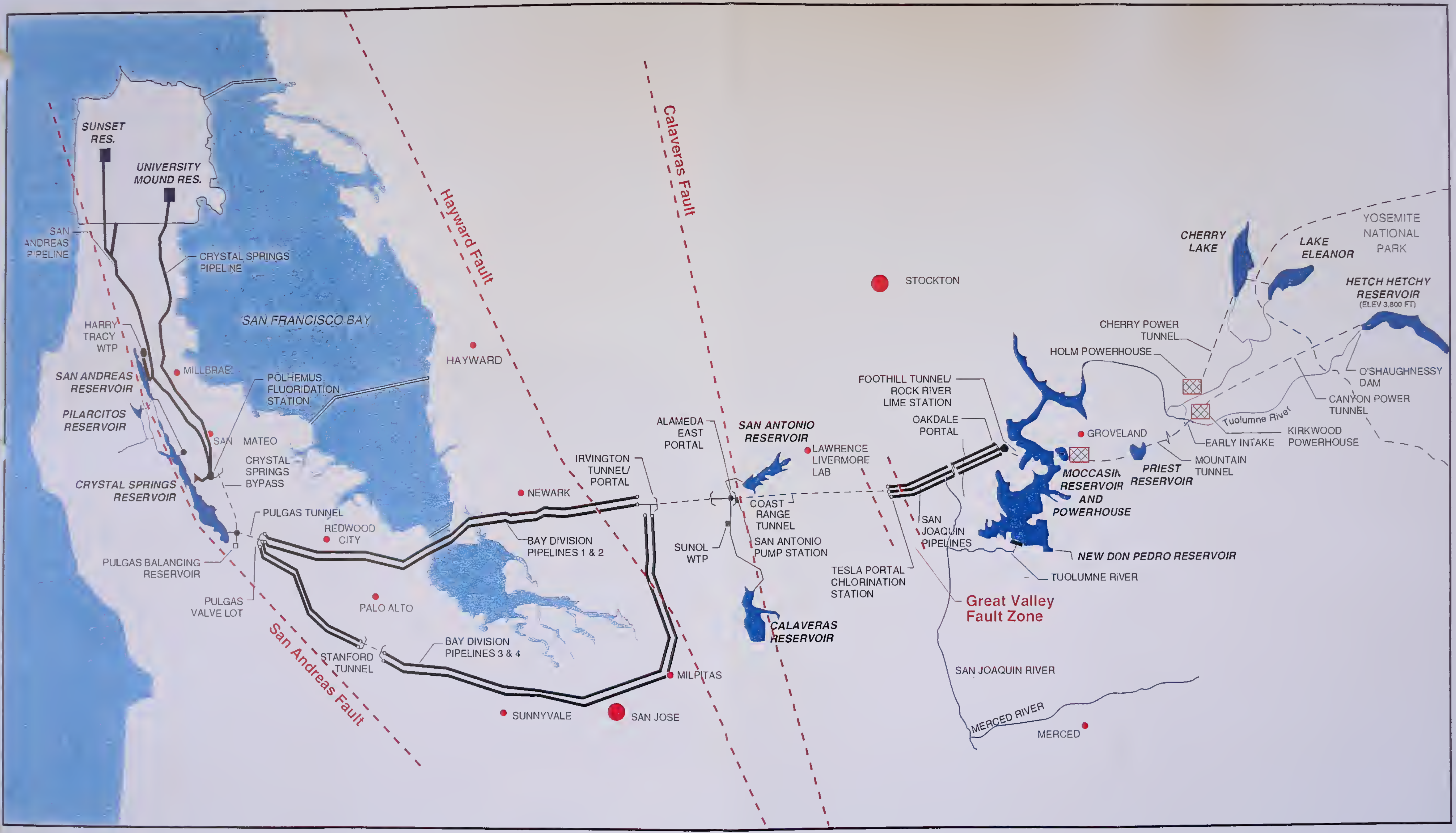
The other two SFPUC system impounding reservoirs on the Tuolumne River, Lake Eleanor and Lake Lloyd (Cherry Lake), are used primarily to satisfy downstream obligations, maintain instream flows below the reservoirs, produce hydroelectric power, and provide river flows for recreation. Although Lake Eleanor and Lake Lloyd do not normally supply water directly to the Bay Area, they allow the SFPUC to manage its river supplies in such a way as to meet its downstream obligations and allow the diversion of water from Hetch Hetchy Reservoir to its Bay Area customers.



SFPUC FACILITIES RELIABILITY PROGRAM

FIGURE 1

OVERVIEW OF REGIONAL SYSTEM FACILITIES



SFPUC FACILITIES RELIABILITY PROGRAM

FIGURE 1

OVERVIEW OF REGIONAL SYSTEM FACILITIES

SFPUC 1083243 011801 5 99 tw

Bay Area System. Water demands are met with a combination of flows from Hetch Hetchy and Bay Area reservoirs. The Bay Area reservoirs conserve local watershed runoff, and water from Hetch Hetchy is imported to supplement the supply to fill customer purchases. Coast Range runoff is stored in Calaveras and San Antonio Reservoirs in the East Bay (Alameda Watershed) and is filtered and disinfected at the Sunol Valley Water Treatment Plant (WTP). The Hetch Hetchy supply is transported from the Coast Range Tunnel through the Alameda Siphons where it is either conveyed as the sole source or is blended with the treated Sunol Valley WTP supply as it enters the Irvington Tunnel. This water is then conveyed through the two sets of Bay Division Pipelines to SFPUC customers in the South and East Bay areas and to the Peninsula and City across San Francisco Bay.

Crystal Springs and San Andreas Reservoirs in San Mateo County provide storage of local runoff and provides terminal storage for "excess" water delivered from the Hetch Hetchy and Sunol Valley supplies that is not directly delivered to SFPUC customers. This water is filtered at the Harry Tracy WTP prior to distribution to Peninsula and City customers.

It has been assumed that at the time of an event the local reservoirs will be at 65 percent capacity. This important assumption was made to cover response scenarios that might occur late in the annual dry season or during short-term drought conditions (long-term drought supply reliability is being considered separately in another study currently underway by the SFPUC). At this level evaluation 65% capacity was considered appropriately conservative in terms of the typical operation of the SFPUC reservoirs. This assumption was developed with the WS&T operations staff.

Table 1
Local (East Bay and Peninsula) Reservoir Capacities

Reservoir	Total Capacity (billion gallons)	65% of Total Capacity (billion gallons)
San Andreas	6.2⁽¹⁾	4.0
Crystal Springs	19.0	12.4
Pilarcitos	0.6	0.4
San Antonio	16.4	10.7
Calaveras	31.5	20.5
Total	**73.7**	**48.0**

(1) The total capacity indicated for San Andreas Reservoir does not take into account the reported 2 billion gallons of dead storage for the reservoir. Dead storage will be confirmed for all of the reservoirs in the next phase of the study.

Historical System Operations. The SFPUC operates its water system to optimize the reliability and quality of water deliveries. The Bay Area system and Hetch Hetchy Water and Power Project operations are integrally linked, dependent upon each other to meet system objectives and customer needs.

The Bay Area system provides regulation between water demands, local watershed runoff, and water imported from Hetch Hetchy. Its primary objective is conservation of local watershed runoff for delivery. The collective operation of Bay Area reservoirs and water treatment plants is determined in part by the needs of SFPUC system customers for consistently high quality water.

Depending upon where customers are located along the SFPUC water system determines what source or blend of water is delivered. Customer purchase requirements exceed the supply available from local reservoirs, so the demand is met by augmenting local supplies with deliveries from Hetch Hetchy. The current strategy for water deliveries to the South Bay, for example, is to maintain a relatively constant blend of local watershed treated water and unfiltered Hetch Hetchy supplies, while responding to varying seasonal water demands.

Hetch Hetchy Project reservoir operations are guided by three principal objectives: collection of Tuolumne River watershed runoff for diversion to the Bay Area, fulfillment of SFPUC downstream release obligations, and generation of power. To conserve runoff, Hetch Hetchy system reservoirs are presently drawn down beginning in early winter, relying upon the recurrence and forecast of snow melt to guide the releases.

Water Quality. The Hetch Hetchy Project source is of such high quality that it is one of the few sources exempted from filtration requirements by the U.S. Environmental Protection Agency. This filtration avoidance status requires the SFPUC to adopt watershed management policies and practices designed to protect the source waters from contamination and to continuously monitor its quality.

Federal and state drinking water regulations require water from the Bay Area watersheds to be filtered and treated before it is distributed to customers. The two SFPUC water treatment plants, Sunol Valley and Harry Tracy, provide physical removal (filtration) of particles in the water, and disinfection to inactivate potentially harmful organisms.

2.2 City Distribution Division System

Most of the City's water distribution system was developed during the one hundred-year period between 1860 and 1960, reflecting the patterns and rates of growth in the City. The significant facilities conveying water to City customers are described below, along with a general overview of how the system is operated.

Conveyance of SFPUC System Supplies. The SFPUC system conveys water from several different sources to the City. The source of the water conveyed to the City on any given day depends on the production availability at the Harry Tracy WTP, with the balance of the demand being met from the Hetch Hetchy system. Water is conveyed from these sources to several primary storage reservoirs located throughout the distribution system and directly to retail customers.

Water is conveyed to the City from the Peninsula through several major pipelines in the SFPUC system. One pipeline provides water to the east side of the City distribution system while three additional pipelines serve the west side of the City system. The 60-inch Crystal Springs Pipeline No. 2 conveys water from the Bay Division Pipelines via the Crystal Springs Bypass (containing Hetch Hetchy and/or treated water from Sunol Valley WTP) directly to University Mound Reservoir in the southeast area of the City. The Crystal Springs Pipeline No. 2 conveys about 30 percent of the total supply to the City. The 44-inch Crystal Springs Pipeline No. 1 is a parallel pipeline that is no longer in operation due to a break that occurred in 1973. The proposed construction of a bypass segment to make this pipeline operational by 2001 is undergoing environmental review.

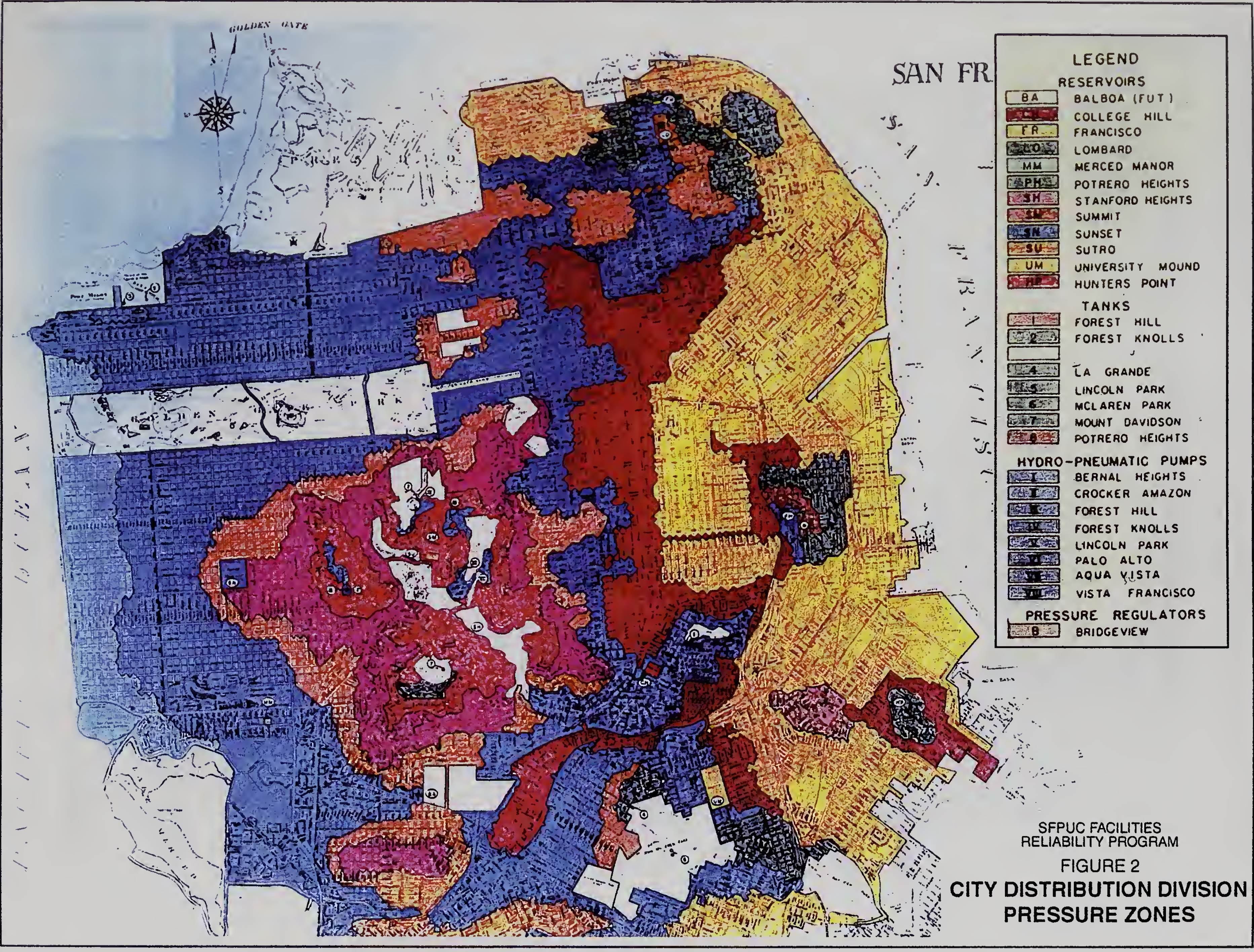
The 60-inch Sunset Supply Line conveys water from either the Crystal Springs Bypass or the Harry Tracy WTP to Sunset Reservoir located in the western area of the City. The 54-inch San Andreas Pipeline No. 2 conveys water from the treatment plant directly to Sunset Reservoir. The 30-inch Baden-Merced Pipeline conveys water from the San Pedro Valve Lot to Merced Manor Reservoir located in the southwest part of the City.

Pressure Zones, Reservoirs, and Pump Stations. The City's distribution system is divided into 19 pressure zones based on elevation and location; the pressure zones are graphically presented in Figure 2. Elevations range from sea level to over 900 feet. There are currently approximately 1,200 miles of water mains, 21 reservoirs and tanks, nine major pump stations and over 15,000 valves within the City. Most of the City reservoir system water is chlorinated on the outlet side of the reservoirs using chlorine or sodium hypochlorite.

The distribution system reservoir and tank storage capacity is about 412 million gallons, which can meet approximately four to five days of average daily demand. However, less than five days of storage is available during high demand periods such as peak days or in the event of a major fire or other catastrophe. The reservoirs are refilled to approximately 90 percent of capacity as quickly as water can be conveyed, usually at night. Energy management is practiced at the Lake Merced Pump Station by maximizing nighttime pumping. In an emergency, such as a catastrophic fire or earthquake, Lake Merced could supply up to 2.5 billion gallons of untreated water. Table 2 below presents both the full capacity of the City's reservoirs; it is assumed that for this baseline reliability analysis, 80 percent of this capacity (330 mgal) is available at the time of the event.

Table 2
CDD Reservoir Capacities

Reservoir	Total Capacity (mgal)	80% of Total Capacity (mgal)
Sunset	174.8	139.8
University Mound	140.9	112.7
Sutro	31.4	25.1
College Hill	14.1	11.3
Summit	14.0	11.2



SFPUC FACILITIES
RELIABILITY PROGRAM

FIGURE 2

**CITY DISTRIBUTION DIVISION
PRESSURE ZONES**

Reservoir	Total Capacity (mgal)	80% of Total Capacity (mgal)
Stanford Heights	12.9	10.3
Merced Manor	9.5	7.6
McLaren Park Tanks	8.0	6.4
Lombard	3.3	2.6
Hunter's Point	1.1	0.9
Potrero	1.0	0.8
Total	**412**	**330**
Francisco*	2.5	2.0
*Not in service		

The majority of the water distributed throughout the City passes through either University Mound Reservoir or Sunset Reservoir. University Mound Reservoir provides water to the large, lower pressure zone. The University Mound pressure zone, which is the second largest pressure zone, generally comprises the east side of the City, including the downtown commercial areas, the major industrial areas and the rest of the Bay waterfront. Two additional lower zones are served from the University Mound Reservoir in the southeast area of the City. Service to downtown is dependent on two pipelines conveying water from University Mound Reservoir that pass through old creek beds and potential liquefaction zones.

The Sunset Reservoir provides water not only to the largest pressure zone, but also to numerous other reservoirs and pressure zones within the City. The Sunset Reservoir pressure zone is located primarily on the west side of the City and wraps around Twin Peaks. It extends as far north as the Lombard pressure zone and as far east as Potrero Heights pressure zone. Water is conveyed through the San Andreas Pipeline No. 2 and the Sunset Supply Line to the Sunset Reservoir. Most reservoirs in this pressure zone are replenished with water pumped from the numerous pumping plants.

The Lake Merced Pump Station, located in the southwest corner of the City, is a critical system facility for many pressure zones. This pump station has a capacity of 50 million gallons per day. Also important to the small, high elevation pressure zones and reservoirs located throughout the City is the 31-million gallon Sutro Reservoir, between the Sunset Reservoir and the upper zones. Sutro Reservoir water can also be pumped through the Summit pump station to Summit Reservoir. Summit Reservoir is an important facility for fire fighting due to its ability to provide water in the upper zones.

One pipeline connects the east and west pressure zones. The 44-inch Cross Town Pipeline can convey water from University Mound Reservoir, located in the east, to the Sunset Reservoir in the west, using the Alemany Pump Station, or from Sunset to University Mound by gravity. This pipeline is normally used to supply the College Hill pressure zone and reservoir.

A System Control and Data Acquisition (SCADA) capability system is being implemented which will connect all of the reservoirs and pump stations to a centralized computerized telemetry system. Approximately 80 percent of the system facilities have been connected to date. The SCADA operations center is located at the Lake Merced Pump Station.

Backup power is provided at most of the pump stations either through permanent generators located on-site or with portable generators, which can be transported to the pump stations. However, the City has eight hydropneumatic stations in the upper zones which are difficult and time-consuming to restore after a power outage.

Although an auxiliary fire fighting system, also known as the Auxiliary Water Supply System (AWSS), is available in some parts of the City, firefighters first utilize the City distribution system supply if it is a small fire and a hydrant is close by. During fires larger than a one-alarm blaze, SFPUC staff is dispatched to the scene to operate the valve system to ensure the availability of adequate water supplies.

3.0 APPROACH TO BASELINE RELIABILITY

3.1 Definition of Baseline Reliability

Reliability is defined, in the context of the SFPUC Facilities Reliability Program, as the ability of the system to meet water delivery requirements following a catastrophic event. The baseline reliability characterization analyzed, at a general level, the assumed ability of the water system to meet system demands following several seismic events, under existing operational and emergency response scenarios.

3.2 TM No. 2 Assumptions

To characterize the reliability of the SFPUC system, key assumptions were developed and presented in TM No. 2. These key assumptions need further analysis in Phase III to provide a greater level of detail and technical accuracy. The assumptions identified in TM No. 2 are summarized below.

Critical Facilities. Critical facilities were identified during Phase I. The operational roles of these facilities were reviewed during Phase II to determine how the facilities were linked in terms of providing a flow of water through the system. If any of these facilities or groups of facilities were to fail, a determination was made as to the ability of other facilities to provide some level of service. Facilities were added to the critical facilities list if they contributed to the ability to flow around the failed facilities, or if they performed a unique function required to meet demands.

Selected Hazard Events. Based on hazard information developed in Phase II TM No. 1, hazard events that pose the greatest concern to the SFPUC system were selected for the baseline reliability characterization. The hazard events selected include those associated with a seismic event at the following locations:

- San Andreas Fault;
- Hayward Fault;
- Calaveras Fault; and
- Great Valley Fault Zone.

Impacts associated with other hazards may have more isolated impacts, versus regional impacts, to system facilities (see TM No. 3 Appendix A. Facility Linkages and Function/Operational Relationships).

Vulnerability of Facilities. The purpose of establishing assumptions regarding the vulnerability of critical facilities was to consider each facilities' likelihood to complete its function for delivering water to SFPUC customers following an event. Based on the Phase II TM No. 1 hazard information, the earthquakes with the greatest potential for impacting each critical facility were identified. The Phase I assignment of degree of risk was utilized and facilities with a moderate or low degree of risk were reassessed using

Phase II TM No. 1 data on peak ground accelerations (PGA). Generally, if the facilities had a high PGA, the degree of risk for that particular facility was increased. All facilities with a high degree of risk were assumed to fail completely following a catastrophic event.

Demand Assumptions. It is assumed that the system is experiencing average day demands (ADD) at the time of the catastrophic event. These ADD have been grouped by subsystems for the regional analysis and are summarized in Table 3 below. If the event occurred at a time when system demands were greater than ADD, it would have little impact on the assumptions utilized for system demands following the event. It may require, however, additional demand management efforts by the SFPUC of its customers but this was not considered significant to the development of the baseline reliability at this level of evaluation. Assumptions for demands of the SFPUC system prior to the event will be evaluated in detail in the next phase of this study.

Table 3
SFPUC System
Average Day Demands by Subsystem

Subsystem	Assumed ADD Within Subsystem
Hetch Hetchy	2 mgd
Sunol Valley	1 mgd
South Bay	107 mgd
Crystal Springs	40 mgd
San Andreas	30 mgd
City Distribution	West – 30 mgd East – 50 mgd
Total	**260 mgd**

The anticipated water demands of the SFPUC system following an event were identified in Phase II – TM No. 2 Baseline Reliability Assumptions for use in the baseline reliability characterization. Assumptions regarding water demands following an event are needed to evaluate the system's ability to meet some level of system demands over time. These demand assumptions reflect typical regional water needs of the system following an event and are summarized in Table 4 below. For this conceptual level evaluation the Table 4 response demands seemed appropriate based on the typical recovery of large water systems to seismic events such as in Kobe, Northridge, and the severely damaged areas of the Bay Area following the Loma Prieta earthquake. These assumptions are not specific to the SFPUC system and could have application to the customer systems of the SFPUC as well.

Table 4
System Demand Assumptions (with Rationing)
Following a Catastrophic Event

Time Frame	Demand Assumption
Prior to Event	Average Day Demand (ADD) of SFPUC system: 260 mgd
0 to 24 hours following an event – for the impacted subsystems	2 times ADD for Regional System and for CDD
0 to 24 hours following an event – for the subsystem outside the impacted subsystems	ADD
24 hours to 20 days – for the impacted subsystems	30 percent of ADD for Regional System; 50 percent of ADD for CDD
24 hours to 20 days – for the subsystem outside the impacted subsystems	50 percent of ADD
20 days to 30 days – for the impacted subsystems	Gradually up to ADD
20 days to 30 days – for the subsystem outside the impacted subsystems	ADD
After 30 days – all subsystems	ADD to maximum day demand

Repair Times. Timeframes for the temporary repair of critical facilities following an event were recommended as a part of the Phase II effort to augment the Phase I determination of permanent restoration times. Temporary repair times are important assumptions for baseline reliability characterization because they identify when failed critical facilities may be brought back on-line to provide some level of service, even if not to full capacity.

Table 5
SFPUC System Restoration Times
Temporary Facility Repair – San Andreas Seismic Event
Days following the Event

Facility Type	Time to Complete Temporary Repairs(1)
Pipelines (including BDPL 4)	30 days
BDPL No. 3	20 days
BDPL Nos. 1 & 2 Pulgas to Redwood City	30 days
BDPL Nos. 1 & 2 Redwood City to Newark	Indefinite
Tunnels	30 to 60 days
Reservoir Adits (3)	30 days
Harry Tracy WTP	3 to 6 days(2)
Pump Stations	2 days(2)
Valve lots	30 days
Storage tanks	25 to 30 days

(1) Temporary restoration capabilities are conceptual estimates based on the experiences and judgement of other utilities. These temporary restoration capabilities will be more rigorously defined for the SFPUC system in Phase III. Times shown are based on one crew being available for each facility repair.

(2) Assumes only mechanical repairs required – if structural damage occurs, time required is longer.
(3) Reservoir Adits were assumed to have different recovery times than more generic categories of tunnels and pipelines as proposed by WS&T staff.

Table 6
SFPUC System Restoration Times
Temporary Facility Repair – Hayward Seismic Event
Days following the Event

Facility	Time to Complete Temporary Repairs[1]
BDPL No. 3	20 days
BDPL No. 4	30 days
BDPL Nos. 1 & 2 Pulgas to Redwood City	30 days
BDPL Nos. 1 & 2 Redwood City to Newark	Indefinite
Irvington Tunnel	30 to 60 days
Irvington Portal	30 days
Alameda Siphons	30 days

Table 7
SFPUC System Restoration Times
Temporary Facility Repair – Calaveras Seismic Event
Days following the Event[1]

Facility Type	Time to Complete Temporary Repairs[1]
San Antonio Pump Station	2 days[2]
Sunol Valley WTP	3 to 6 days[2]
Alameda Creek Siphons	30 days
Irvington Tunnel	30 – 60 days
Turner Adits [3]	30 days
BDPL Nos. 1 & 2 – Pulgas to Redwood City	30 days
BDPL Nos. 1 & 2 – Redwood City to Newark	Indefinite
BDPL No. 3	20 days
BDPL No. 4	30 days

(1) Temporary restoration capabilities are conceptual estimates based on the experiences and judgement of other utilities. These temporary restoration capabilities will more rigorously be defined for the SFPUC system in Phase III. Times shown are based on one crew being available for each facility repair.
(2) Assumes only mechanical repairs required – if structural damage occurs, time required is longer.
(3) Reservoir Adits were assumed to have different recovery times than more generic categories of tunnels and pipelines as proposed by WS&T staff.

Table 8
SFPUC System Restoration Times
Temporary Facility Repair – Great Valley Seismic Event
Days following the Event

Facility Type	Time to Complete Temporary Repairs
San Joaquin Pipelines	30 days
Tesla Portal	30 days
Coast Range Tunnel	30 – 60 days
Thomas Shaft Disinfection Station	30 days

Supply Availability. It was assumed that 65 percent of the total raw water storage capacity was available at the time of an event. This reduced capacity assumption accounts for unusable storage capacity as well as the event occurring during times of reduced storage (from seasonal fluctuations for the regional system and daily fluctuations for the CDD). For CDD, 80 percent of the reservoir and tank capacities are assumed to be available.

3.3 Approach

The approach to characterizing the baseline reliability of the SFPUC system is based on the following key steps. The use of these assumptions and the remaining steps are presented here in TM No. 3 for each hazard event.

A time sequence analysis was conducted to determine how the existing system may respond under the selected hazard events over time. The time sequences utilized for the regional system response are summarized below.

Table 9
Time Sequence Utilized for System Regional Response Scenarios

Sequence Number	Description
Time 1	At the time of the event
Time 2	Immediately after the event (1 to 2 hours)
Time 3	2 to 24 hours after the event
Time 4	24 hours to 20 days after the event
Time 5	20 days to 30 days after the event
Time 6	30 days after the event

Time sequences utilized for the CDD system response are slightly different than those shown above due to the nature of the CDD system and operation. CDD response time sequences are summarized below.

Table 10
Time Sequence Utilized for CDD Response Scenarios

Sequence Number	Description
Time 1	At the time of the event
Time 2	0.5 to 24 hours after the event
Time 3	24 hours to 3 days after the event
Time 4	3 days to 30 days after the event

The analysis and results are presented in the next section. The resulting baseline reliability characterization provides an understanding of how the existing system facilities are linked operationally and from a regional perspective, it aids in identifying the weak links and problem areas in the system, and results in a general assessment of the system in terms of a high, medium, or low level of reliability. The approach is shown graphically on Figure 1:

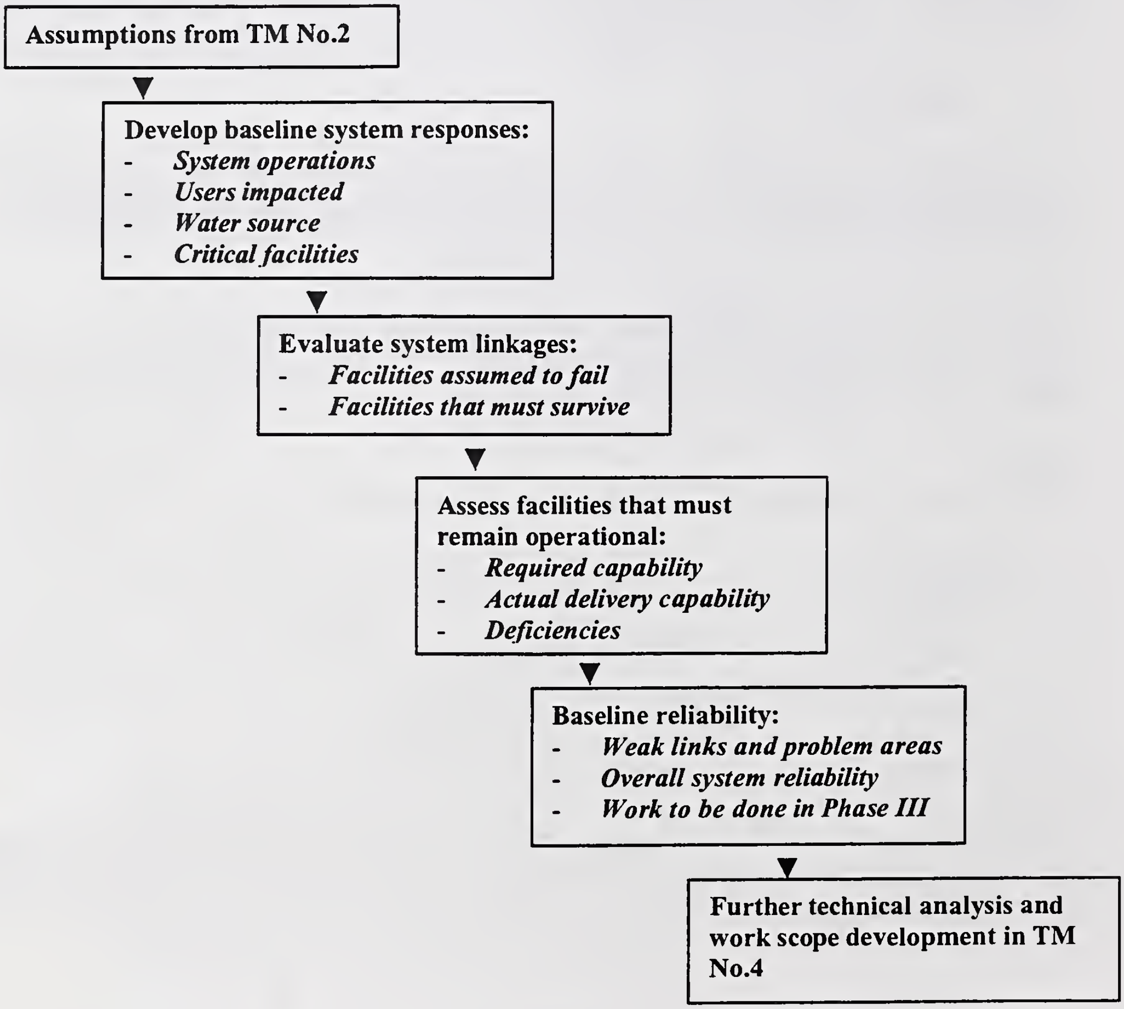

Assumptions from TM No.2
Develop baseline system responses:
- System operations
- Users impacted
- Water source
- Critical facilities
Evaluate system linkages:
- Facilities assumed to fail
- Facilities that must survive
Assess facilities that must remain operational:
- Required capability
- Actual delivery capability
- Deficiencies
Baseline reliability:
- Weak links and problem areas
- Overall system reliability
- Work to be done in Phase III
Further technical analysis and work scope development in TM No.4

Figure 3
Baseline Reliability Evaluation Approach

4.0 BASELINE SYSTEM RESPONSES

The following discussion presents a reconnaissance-level time lapse response of the SFPUC system to a magnitude 7.9 seismic event on the San Andreas Fault, a magnitude 7.1 seismic event on the Hayward Fault, a magnitude 6.8 seismic event on the Calaveras Fault and a magnitude 6.7 seismic event on the Great Valley Fault. These events have been selected to determine the reliability of the overall SFPUC system in an event that impacts multiple facilities simultaneously and to highlight the overlapping weak links and problem areas. The results will be used to identify immediate system improvements and long-term studies leading to alternative solutions required to improve the reliability of the overall system.

The responses are presented individually for each event (San Andreas Fault, Hayward Fault, Calaveras Fault and Great Valley Fault). For the San Andreas Fault event, responses are described separately for the regional system and the CDD system due to the differences in operations and response priorities between these systems. Each response description includes a discussion on system operations, users impacted and water source for each selected time following the event (see Time Sequences table above).

4.1 San Andreas Fault Event Response

4.1.1 Regional System Response to San Andreas Fault Event

The following discussion presents a response of the SFPUC system to magnitude 7.9 seismic event on the San Andreas Fault, which will in turn determine the reliability of the SFPUC system for this particular event.

System demand is approximately average day demand or 260 mgd. This demand is being supplied from multiple SFPUC water supply sources including the following.

- 200 mgd from Hetch Hetchy
- 40 mgd from Calaveras via the Sunol Valley WTP
- 40 mgd from Crystal Springs via the Harry Tracy WTP

The excess flow from Hetch Hetchy and the Sunol Valley WTP typically spills to Crystal Springs Reservoir.

SFPUC system reservoirs are approximately two-thirds full at the time of the event.

Regional System Response
Time 1: At the time of the San Andreas Fault event

A magnitude 7.9 seismic event occurs on the San Andreas Fault. The SFPUC system facilities experience peak ground accelerations of 0.2g to 0.9g from approximately the east portal of the Coast Range Tunnel, across the Bay, up to CDD. The entire Peninsula is anticipated to experience accelerations of 0.5g and above. The highest ground accelerations, 0.6g to 0.9g, are anticipated to be in the South Bay vicinity of the Palo Alto, Redwood City and Pulgas, along the eastern Peninsula from Hillsborough to San Bruno, and along the northern Peninsula from Colma into the western areas of the City. The UBC design requirements for the Bay Area (Seismic Zone 4) is 0.4g, however, anything above 0.2g is considered high acceleration.

System demand at the time of the event is average annual day demand or 260 mgd.

System operations:

Based on the Phase I Study results and the additional hazards information outlined in TM No. 1 (i.e., facilities experiencing PGAs of 0.5g or greater), the facilities highlighted in Table 11 would be highly vulnerable to this event and were assumed for this reconnaissance level evaluation to fail following the event. These facilities assumed to fail are also shown on Figure 4.

Table 11
Facilities Assumed to have failed following
A Magnitude 7.9 Seismic Event on the San Andreas Fault

BDPL Nos. 1 & 2
BDPL Nos. 3 & 4
Pulgas Tunnel and Valve Lot
Crystal Springs Bypass Pipeline and Tunnel
Pulgas Balancing Reservoir and Pump Station
Crystal Springs Pump Station
Pilarcitos Dam, Reservoir & Tunnel
Crystal Springs-San Andreas Pipeline
Crystal Springs Pipeline Nos. 2 and 3
University Mound Feeder Mains
Harry Tracy WTP
San Andreas Pipelines Nos. 2 and 3
Baden Pump Station
Sunset Supply Line
Lake Merced Pump Station

The western portion of the BDPLs Nos. 3 and 4 are assumed to fail either because of a partial or complete pipe and/or valve system failure. BDPL's Nos. 1 and 2 are assumed to fail anywhere from the Newark Valve Lot west. In addition, SFPUC facilities in the Pulgas area, including the Pulgas Tunnel, Pulgas Pump Station, Balancing Reservoir and the Crystal Springs Bypass Tunnel and Pipeline will experience intense ground shaking and cannot be relied upon for service following a San Andreas event. Crystal Springs Reservoir is assumed to be isolated from

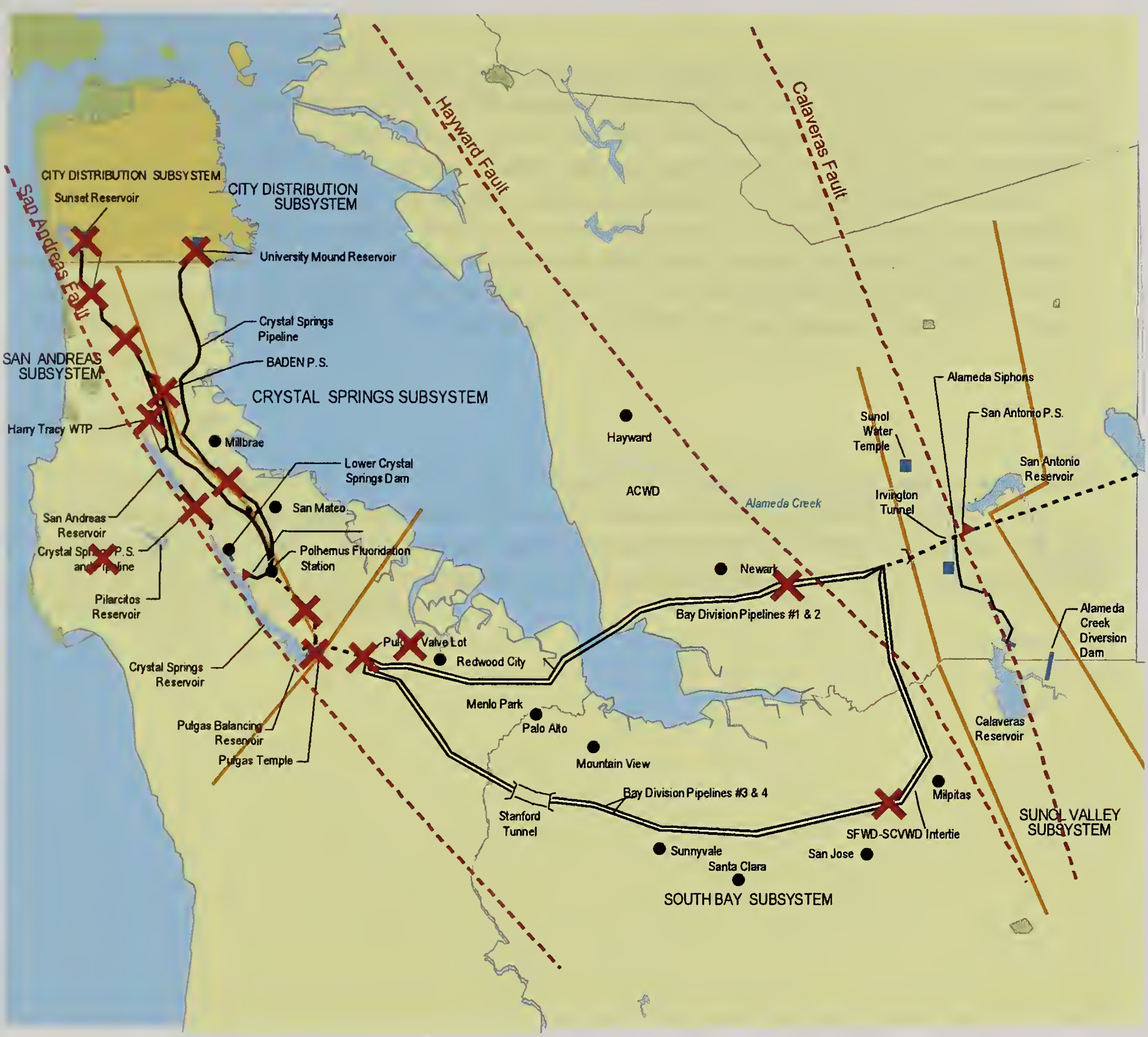


FIGURE **4**
San Andreas Fault Event Response
SFPUC Facilities Assumed to Fail

the system with damage to adits, pump station and the Crystal Springs San Andreas Pipeline. The pipelines along the east side of the Peninsula, including the Sunset Supply Line and Crystal Springs Pipeline No. 2, are anticipated to be at least partially damaged. San Andreas Reservoir is assumed to be isolated with damage to adits and raw water pipelines from the reservoir. The Harry Tracy WTP is assumed to be at least partially damaged and unable to provide its full capacity treatment requirements. The San Andreas Pipelines No. 2 and 3 from the treatment plant are assumed to be damaged, as well as the Baden Pump Station, the Sunset Supply Line and San Andreas Pipeline No. 2 into the City system. The Lake Merced Pump Station was identified as being highly vulnerable and is likely to fail following a seismic event on the San Andreas Fault.

Users impacted:

The majority of the SFPUC system's critical transmission and pumping facilities are anticipated to be damaged and the Peninsula and City system customers will be isolated from the Hetch Hetchy supply, the Sunol Valley supply, and the Peninsula supplies. There is significant leakage in the system and pressure in the damaged areas is assumed to drop immediately to the elevation of Pulgas weir, elevation 303 feet.

Regional System Response
Time 2: Immediately after the San Andreas Fault event (1 to 2 hours)

System operations:

Valves at the Milpitas Valve Lot and the Newark Valve Lot are closed to isolate the unfailed portion of the BDPLs (on the eastern end) from the west side of the system. The Hetch Hetchy supply and the Sunol Valley supply are now cut off from the a portion of the South Bay customers and all of the SFPUC Peninsula and City customers.

On the Peninsula side of the SFPUC system, valves are shut on the BDPLs at the Pulgas Tunnel. Valves are closed at the downstream side of the Pulgas Tunnel, at the Crystal Springs Pump Station, at the Crystal Springs and Sunset Supply Lines, and at the Crystal Springs San Andreas Pipeline, thus isolating the Crystal Springs Reservoir from the remainder of the system. The Pulgas Balancing Reservoir is also isolated from the system, however, it is also anticipated to be out of service due to the high ground shaking estimated for the Pulgas area. The Harry Tracy WTP is out of service. Valves are also closed at San Andreas No. 2 and 3 raw water pipelines and at the Harry Tracy WTP, thus isolating the San Andreas Reservoir from the remainder of the system. Damaged pipelines along the Peninsula are isolated at multiple locations at valve lots that remain undamaged. The Baden Pump Station, and the Lake Merced Pump Station are out of service.

As a result, service to East Bay SFPUC customers served off BDPLs Nos.1 and 2, east of Newark Valve Lot, are served from Hetch Hetchy and/or the Sunol Valley supply. South Bay subsystem customers served by BDPLs Nos. 3 and 4, east of Milpitas valve lot, and possibly east of Mountain View valve lot, also continue to be served from Hetch Hetchy and/or the Sunol Valley supply. The remainder of the system, west through the Peninsula and up to the City system is isolated from SFPUC supplies and is completely dependant on local storage and alternative available water supplies to meet customer demands.

Water from the Harry Tracy WTP clearwell (14.5 mg capacity) may be available, however, the pipelines from the reservoirs to the system may not be fully operational. The system demand is high, however, only the eastern portion of the system is assumed to remain operational, Hayward, ACWD and Milpitas remain on the SFPUC system. The demand on that portion of the SFPUC system is approximately 40 mgd. For the remainder of the system, demand begins to increase significantly because of leaks due to pipeline breaks, storage tank failures and fire flow demands. The total demand of the SFPUC system customers, now isolated from the system, immediately after the event is assumed to be twice the average day demand or approximately 440 mgd. All of this demand must be met from local storage of the Peninsula and City systems. We have not assumed that supply would be available from the Santa Clara Valley Water District (SCVWD) intertie connection to the SFPUC system.

Regional System Response
Time 3: 2 to 24 hours after the San Andreas Fault event

It is assumed that because of the extensive damage anticipated for the SFPUC system under this scenario, crews will only be available during this time period to 1) continue isolating portions of the system that are leaking, and 2) assess the damage to critical facilities in order to develop a priority plan for responding to the repairs needed of the system. The priorities for immediate repair of the system include:

1. Providing access to isolated SFPUC supplies that can provide treated water to the system, and

2. Identifying least damaged backbone transmission pipelines available to distribute treated water to SFPUC customers.

It was assumed for this response evaluation that it is not desirable to introduce untreated water, whether chlorinated or not, into the distribution system. The impact of potentially introducing untreated water into the SFPUC system, and into the SFPUC customer systems, was determined to be more detrimental to the long-term reliability of the system, and potentially the customer systems, than concentrating on fixing the infrastructure to provide treated water to the customers.

System operations:

With these priorities in mind, crews are mobilized to assess damage to the BDPLs, concentrating primarily on the easiest-to-fix BDPL section, BDPL No. 3. Having BDPL No. 3 at least partially operational would allow Hetch Hetchy and/or Sunol Valley supplies to serve South Bay subsystem customers, and potentially customers who tap off BDPL No. 1 and No. 2 from Pulgas to Redwood City.

Crews are mobilized to assess damage to the San Andreas outlet towers and San Andreas Pipelines Nos. 2 and 3. Restoring one of these towers to service and partially fixing one of these pipelines would provide access to the San Andreas Reservoir to provide treated water via the Harry Tracy WTP.

Finally, at Time 2 within this initial 24 hour period, crews are mobilized to assess the serviceability of the Harry Tracy WTP and/or the Baden Pump Station to determine whether one or the other can be made operational, along with damaged transmission pipelines, to serve the upper zone of the system. The Baden Pump Station could be utilized to deliver Hetch Hetchy and/or Sunol Valley supplies to the upper zones if there are enough pipelines in service to get water from the BDPLs to the pump station.

Users impacted:

Demands on the system were assumed to remain very high as the system is utilized to fight fires and as leaks in the system are isolated and/or repaired. Except for the eastern portion of the system being served by the undamaged portion of the BDPLs, this demand continues to be met from local storage and alternative local supplies available to the Peninsula and City systems.

Water source:

In terms of SFPUC supplies that can provide treated water to the system, two emergency response priorities surfaced:

1. Either BDPL No. 3 or 4 needs to be returned to service quickly to serve the South Bay and possibly Peninsula subsystem customers with Hetch Hetchy and/or Sunol Valley supplies;

2. The Crystal Springs Pipeline No.2 needs to be returned to service along with the Baden Pump Station in order to potentially serve the higher zones in the City and possibly the Peninsula customers (Baden P.S. principally serves the higher zone customers when Tracy WTP is out of service by providing water to Sunset Reservoir), or alternatively,

3. Harry Tracy WTP should be returned to service as quickly as possible to serve the higher zones in the City and possibly the Peninsula customers.

Regional System Response
Time 4: 24 hours to 20 days after the San Andreas Fault event

System operations:

The results of facility repair assumptions presented above are that the BDPLs, the Pulgas and Crystal Springs Bypass Tunnels, the major transmission pipelines, and Crystal Springs and San Antonio Reservoir adits remain out of service for the Time 4, 24 hours to 20 days after the event.

Users impacted:

The South Bay subsystem customers served off of the BDPLs west of Newark Valve Lot and Milpitas Valve Lot remain isolated from the SFPUC system. The entire Peninsula and City subsystems remain isolated from the SFPUC water supplies and are dependent on local storage and alternative local supplies.

Water source:

The Baden Pump Station and the Lake Merced Pump Station are available for service after a couple days. The Harry Tracy WTP is operational after about 6 days, however, the water supply sources to and from the treatment plant remain isolated. Demands on the system in the isolated areas are reduced, as the system customers become aware of the damage to the system and the isolation of their SFPUC water supplies.

Regional System Response
Time 5: 20 days to 30 days after the San Andreas Fault event

System operations:

The Baden Pump Station and the Lake Merced Pump Station are available for service. The Harry Tracy WTP is operational, however, the pipelines to and from the treatment plant remain out of service. BDPL No. 3 is repaired and back in service. The remaining BDPLs, the Pulgas and Crystal Springs Bypass Tunnels, the major transmission pipelines, and Crystal Springs and San Andreas adits, remain out of service for the Time 5, 20 days to 30 days after the event.

Users impacted:

South Bay SFPUC customers served from BDPL No. 3 can now be served from Hetch Hetchy and/or the Sunol Valley watershed supply via the Sunol Valley WTP. The capacity of BDPL No. 3 is approximately 110 mgd, which is adequate to meet the demands of the South Bay subsystem customers. South Bay subsystem SFPUC customers served BDPLs Nos. 1 & 2 only such as East Palo Alto, Menlo Park and Skyline County Water District remain isolated from the SFPUC system.

The Peninsula subsystem customers and the City subsystem customers remain isolated from SFPUC supplies. During this time period, 100% of the water supplied to the SFPUC system north of Pulgas continues to be from the alternative local water supplies.

Water sources:

Demands of the system being served by SFPUC supplies, i.e. the South Bay subsystem customers, are ramping back up to average day, or approximately 90 mgd (not including those areas served by BDPL Nos. 1 & 2 only). Total demand of the impacted portion of the system is assumed to remain low, 30 percent of ADD, or approximately 70 mgd. These demands continue to be met by the only water supply available, which is alternative local supplies.

Regional System Response
Time 6: 30 days after the San Andreas Fault event

System operations:

BDPL No. 1 or No. 2 from Pulgas to Redwood City is back in service. (The remainder of BDPLs Nos. 1 and 2 between Redwood City and Newark remain out of service indefinitely.) The capacity of BDPLs at this point is approximately 110 mgd, as limited by the capacity of BDPL No. 3, which is adequate to meet the average day demands of the South Bay subsystem customers.

Users impacted:

South Bay SFPUC customers served off of BDPL No. 1 or No. 2 between Pulgas and the Redwood City valve lot can now be served from Hetch Hetchy and/or the Sunol Valley supply. SFPUC customers served off of BDPL Nos. 1 and 2 east of the Redwood City valve lot, including East Palo Alto, Menlo Park and customers served exclusively off of the Palo Alto Pipeline, remain isolated from the system.

Water sources:

The Pulgas and Crystal Springs Bypass Tunnels remain out of service for up to 60 days after the event, which means that Belmont County Water District and Filoli remain isolated from the system. Also, the Peninsula and City SFPUC customers remain cut off from the Hetch Hetchy and/or Sunol Valley supplies. As mentioned previously, the Harry Tracy WTP is operational after 3 to 6 days. At time 6, 30 days after the event, critical transmission facilities to and from the Harry Tracy WTP are now operational which mean these customers, although isolated from Hetch Hetchy and the Sunol Valley supplies, can be served San Andreas Supply via the Harry Tracy Supply. The backbone transmission facilities assumed to be back in service in order to deliver treated water from the Harry Tracy WTP include the following:

Table 12
"Backbone" Transmission Facilities to and from Harry Tracy WTP
Back in Service at Time 6, 30 days following the San Andreas Fault

Raw Water Piping San Andreas Reservoir Adit 2 or 3
San Andreas Reservoir RW 2 or 3
Treated Water Piping San Andreas Pipelines No. 2 or 3
Baden Pump Station
Service South from HTWTP Crystal Springs Pipeline No. 2 or Sunset Supply Pipeline to Baden Pump Station
Crystal Springs Bypass Pipeline
Service North from HTWTP San Andreas Pipeline No. 2 or Sunset Supply Line from Baden PS to Sunset Reservoir
University Mound Feeder Mains
Lake Merced Pump Station only if Sunset Supply Line is utilized

It is assumed that the valve lots on the transmission pipelines indicated are critical to the system operation and are assumed to be operational as well. As indicated in the table, not all of the pipelines and/or pump stations are assumed to be operational at 30 days following the event, just those required to complete the "backbone" transmission system. The final determination of which transmission options will be fixed first will be based on 1) the serviceability of existing pipelines, and 2) the ability to repair damaged pipelines connected to the operational pipelines. However, it appears that, at this reconnaissance level evaluation, there is adequate redundancy in the turnouts to Peninsula customers that either option would include service to the majority of SFPUC customers.

As a result, the majority of the Peninsula and all of the City customers can now be served treated water from San Andreas Reservoir via the Harry Tracy WTP. The Harry Tracy WTP is ramped up to its maximum flow rate of 144 mgd. Demands on the system north of Pulgas were assumed to be ADD (even though they have been severely reduced for the previously 30 days), or approximately 150 mgd. Of this 150 mgd demand, 70 mgd is from the Peninsula customers, and approximately 80 mgd is from the City system. Harry Tracy capacity is assumed to be capable of meeting these demands.

4.1.2 City Distribution Division (CDD) Response to San Andreas Fault Event

The following discussion presents a reconnaissance level time lapse response of the SFPUC's CDD system to a magnitude 7.9 seismic event on the San Andreas Fault, which will, in turn, determine the reliability of the CDD system for this particular event.

Assumptions:

Average day system demand is 80 mgd being supplied from the following sources and primary conveyance facilities.

- 40 mgd from San Andreas Reservoir via the Harry Tracy WTP and San Andreas pipelines 1 & 2, Sunset Supply, Baden-Merced pipelines and Sunset branch pipelines
- 40 mgd from Hetch Hetchy system via the Crystal Springs Pipeline No. 2
- 330 mgd (80 percent of capacity) stored in CDD system reservoirs

CDD Response
Time 1: At the time of the San Andreas Fault event

System operations:

A magnitude 7.9 seismic event occurs on the San Andreas Fault. As discussed above under the regional system impacts from the San Andreas event, the SFPUC system facilities experience high peak ground accelerations (PGAs) on the Peninsula. Therefore, the SFPUC system supplies are not available to the CDD due to breaks in the Crystal Springs, San Andreas, Sunset Supply, and Baden-Merced pipelines.

Within the City, high PGAs are also experienced. The Sunset, University Mound, College Hill, and Summit reservoirs may have collapsed roofs. The remaining reservoirs and tanks may also be damaged, but the supply is also assumed to be available. The outlets on all of the reservoirs and tanks are assumed to be in working conditions and water from all of the reservoirs and tanks are draining into the distribution system immediately following the event.

Power is out throughout the City. The pump stations are out of service due to power outage and damage; the Lake Merced and Central Pump Stations have failed. There may be much more pump station and reservoir damage than anticipated in the Phase I report; the new hazard data developed for Phase II indicates very high PGAs for the San Andreas event.

There is extensive damage to both the pipelines conveying water to the reservoirs and to the distribution system pipelines. As a indicator of the extent of pipeline damage, a study funded by the Federal Emergency Management Agency in 1991, “A Model Methodology for Assessment of Seismic Vulnerability and Impact of Disruption of Water Supply Systems”, used the CDD system for its application of the recommended methodology. It indicated that under a San Andreas 8.3 event, 925 pipeline breaks were associated with this hypothetical event, due to liquefaction and ground shaking.

CDD Response
Time 2: 0.5 to 24 hours after the San Andreas Fault event

System operations:

The system demands are anticipated to increase to about 175 mgd within this first 24 hours. This demand reflects a reduced customer demand of 50 percent of ADD plus fire fighting requirements. Because of the fire fighting needs, the extensive pipeline breakage, and the lack of seismic valving at the reservoirs, the reservoirs are draining rapidly. The reservoirs with collapsed roofs are draining nonpotable water into the distribution system. Crews are isolating reservoirs and pipelines to prevent full reservoir losses in areas where the water supply is not required for fire fighting. The pipelines distributing water from the reservoirs are assumed to have failed due to pipe breaks; the smaller pipes can continue conveying water, although not at the same flow rate and pressure.

At the end of this time frame, it is assumed that all of the upper pressure zone facilities are drained, and most of the remainder of the system reservoirs and tanks have about one to two average days of supply retained. Where the AWSS is available, it is meeting much of the fire fighting requirements; the remaining areas of the City, principally west of Twin Peaks, are relying on the distribution system supply.

The permanent backup generators are being activated; several of the mobile generators are being transported by crews to the pump stations without permanent generators, and activated.

Users impacted:

Pressure zones served by the hydropneumatic facilities, and the upper pressure zones (see Figure 2) lose water service as the tanks and reservoirs drain due to pipe breaks and fire fighting needs, and the water is not replenished. The pipelines distributing University Mound Reservoir water pass through areas with high potential for liquefaction, and are assumed to break in multiple locations. The most seriously impacted area (in terms of broken pipes) of the University Mound pressure zone, from "South of Market" north including downtown and the northern waterfront, will have water available only through small pipe connections from adjacent upper zones.

Water source:

The CDD system is isolated from the SFPUC supply due to the Crystal Springs, Sunset Supply, Baden-Merced, and San Andreas pipe breaks. The AWSS is located in parts of the heavily impacted area and is assumed to be available to help fight fires during this time frame when it is needed most. The rest of the system is supplied water through intact pipelines from the draining reservoirs and tanks.

CDD Response
Time 3: 24 hours to 3 days after the San Andreas Fault event

System operations:

Customer demands throughout the system have decreased by up to 50 percent of ADD due to the lack of availability of supply and the City's encouragement of customer demand reductions. The pipelines supplying the CDD with the SFPUC supply are not restored within this time frame.

The pipelines from the Sunset and University Mound reservoirs are not repaired. Smaller intact pipes are distributing the remaining water supply within these pressure zones and to lower zones. For example, areas in the College Hill pressure zone can drain into the lower University Mound zone, but the distribution capacity is limited. The most seriously impacted area is the University Mound pressure zone due to the extensive pipe breaks anticipated in the liquefaction zone. There is a lack of sufficiently sized pipelines located outside of the liquefaction zones and a lack of storage in the north part of the City.

Water source:

It is assumed that the Alemany Pump Station is still operational, using back up power, but since the Cross Town Pipeline has failed, the pump station cannot pump any University Mound water to the west side of the City. The University Mound and Sunset reservoirs are drained by the end of this time period. For the rest of the pressure zones, all tanks and reservoirs are also drained by day three. Although backup power generators are available for the remaining pump stations or hydropneumatic stations, the supply from the regional system is still not available. The mains and pump stations are being repaired during this time frame.

CDD Response
Time 4: ***3 days to 30 days after the San Andreas event***

System operations:

During this timeframe, pump stations, mains, and smaller pipelines are being repaired, and reservoirs and tanks are being checked and repaired, as needed. Power is restored early during this timeframe.

Water source:

The Lake Merced water supply may be able to be connected to the pumps that have been repaired at the Lake Merced Pump Station. This non-potable supply could meet the system demands in areas that can be served by the Lake Merced pump station that have restored pipes. (The 1.9 billion gallons is equivalent to about 25 days of ADD.) However, this supply does not meet potable standards. As is the case with the pressure zones receiving water from the reservoirs will collapsed roofs, the pressure zones receiving this nonpotable water would have to be shut down and flushed with disinfected water as the potable supply becomes available. This would cause serious interruptions to the system at a time when the water demands have increased back to an average day level.

Pressure zones that are not connected to the Lake Merced Pump Station, and therefore could not receive Lake Merced water, include Merced Manor, Stanford Heights, and Mt. Davidson. College Hill pressure zone and the southern part of University Mound zone could receive this water if the Cross Town Pipeline is restored, which is not anticipated until after this timeframe.

The existing groundwater wells could also be utilized. The current capacity of 4 mgd is likely to be available within this time frame, after the facilities have been inspected and the pipeline connections repaired, as necessary. This 4 mgd is currently used for the irrigation of parks and at the San Francisco Zoo.

Users impacted:

There is no potable supply available from the SFPUC system during this time frame. If there was a water supply, system demands would be increasing during this time from about 50 percent of ADD back up to ADD by the end of the time frame.

Water source:

Transmission system to the CDD, after 30 days, water service can be restored to much of the system that has been repaired. It is likely that the downtown area will take the longest to have service fully restored.

4.2 Hayward Fault Event Response

The following discussion presents a reconnaissance level time lapse response of the SFPUC system to magnitude 7.1 seismic event on the Hayward Fault, which will in turn determine the reliability of the SFPUC system for this particular event.

Assumptions:

System demand is approximately average day demand or 260 mgd. This demand is being supplied from multiple SFPUC water supply sources including the following.

- 200 mgd from Hetch Hetchy
- 40 mgd from Calaveras via the Sunol Valley WTP
- 40 mgd from Crystal Springs via the Harry Tracy WTP

The excess flow from Hetch Hetchy and the Sunol Valley WTP typically spills to Crystal Springs Reservoir.

SFPUC system reservoirs are approximately two-thirds full at the time of the event.

Time 1: At the time of the Hayward Fault event

System operations:

A magnitude 7.1 seismic event occurs on the Hayward Fault. The SFPUC system facilities experience peak ground accelerations of 0.2g to 0.8g from approximately Mitchell Shaft on the Coast Range Tunnel (to the east) to the Redwood City (to the west). The UBC design requirements for the Bay Area (Seismic Zone 4) is 0.4g, however, anything above 0.2g is considered high acceleration.

Based on the Phase I Study results the facilities listed in Table 13 would be highly vulnerable to this event and were assumed for this reconnaissance level evaluation to not be operational following the event. These facilities assumed to have failed are and also shown on Figure 5.

Table 13
Facilities Assumed to have failed following
A Magnitude 7.1 Seismic Event on the Hayward Fault

San Antonio Pump Station
Sunol Valley WTP
Alameda Creek Siphons
Irvington Tunnel
BDPLs Nos. 1&2
BDPLs Nos. 3&4

The Alameda Siphons fail; the Irvington Tunnel west portal collapses and there is significant leakage; and the BDPLs fail either because of a partial or complete pipe and/or valve system failure. In addition, the Sunol Valley facilities are assumed to be damaged and not operational. Water spills at Alameda East and West Portals. Hetch Hetchy and Sunol Valley supplies are isolated from the system and SFPUC customers. Pressure in the system drops almost immediately to the elevation of Pulgas weir, elevation 303 feet. Harry Tracy WTP is operating at 40 mgd to deliver water to the west side of the Peninsula and the upper elevations of the City system.

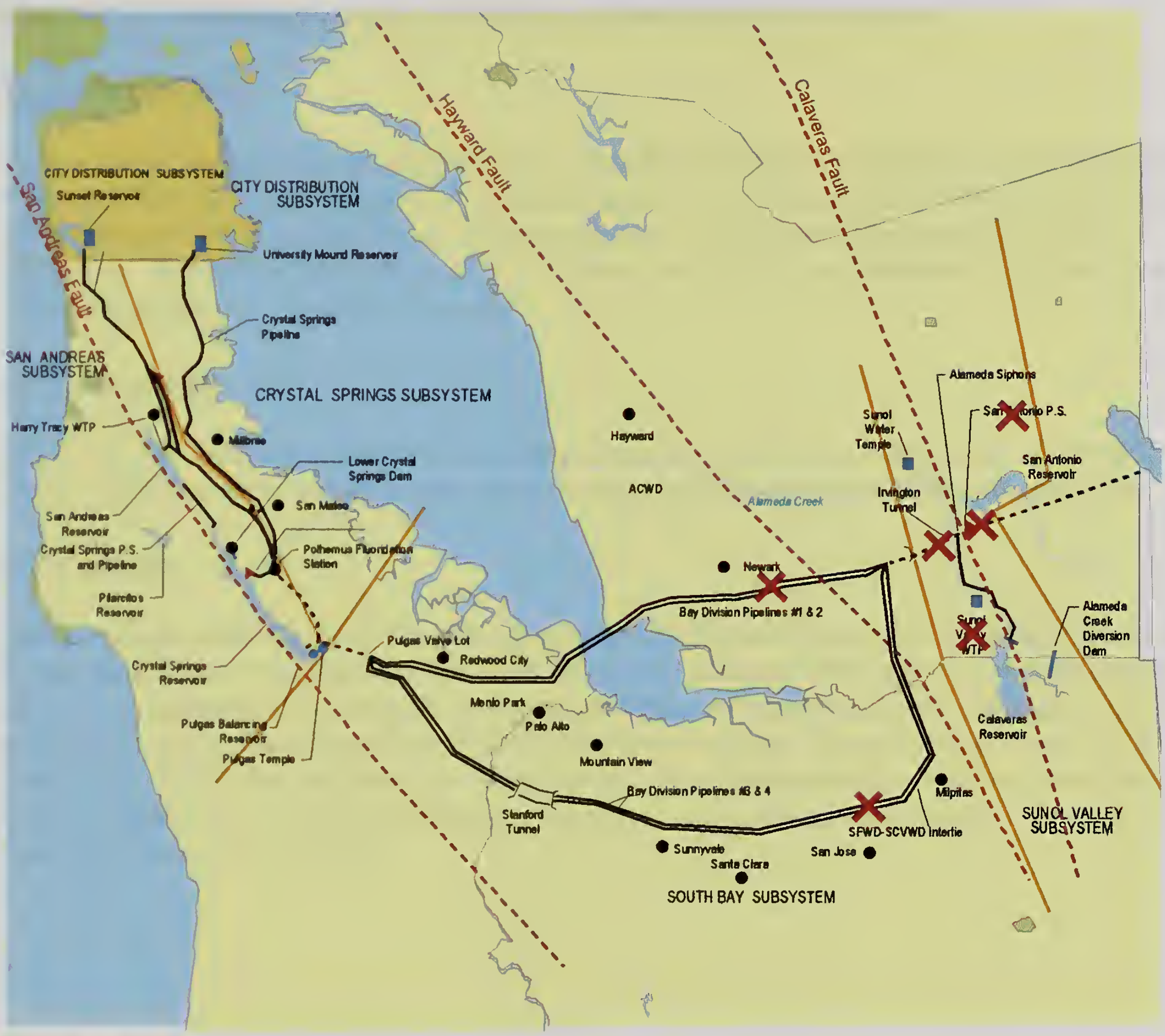


FIGURE **5**
Hayward Fault Event Response
SFPUC Facilities Assumed to Fail

Time 2: ***Immediately after the Hayward Fault event (1 to 2 hours)***

System operations:

Valves at the Coast Range Tunnel are closed, shutting down the supply from Hetch Hetchy and forcing Hetch Hetchy water into San Antonio Reservoir. Valves are also closed at the Alameda West Portal and at Irvington Portal isolating the Sunol Valley facilities from the SFPUC customers. On the west end of the SFPUC system, valves are shut upstream of Pulgas Tunnel to isolate the BDPLs to assess the damage.

Users impacted:

The South Bay subsystem SFPUC customers served from BDPLs are isolated from the SFPUC system and dependant completely on local storage and alternative available water supplies.

Water source:

The system demand begins to increase significantly because of leaks due to pipeline breaks, storage tank failures and fire flow demands. The total demand of the system immediately after the event is assumed to be twice the average day demand or approximately 300 mgd. Of this demand, 40 mg would be met from Pulgas Balancing reservoir, 40 mgd would be met from Harry Tracy WTP, and the remainder would be met from local storage of the Peninsula and City systems. Harry Tracy WTP would begin ramping up to its maximum flow rate, currently 144 mgd, which takes 4 to 6 hours.

Time 3: 2 to 24 hours after the Hayward Fault event

System operations:

Crews are mobilized to fix the damaged BDPLs, concentrating primarily on the least vulnerable BDPL section, BDPL No. 3. In addition, crews are mobilized to fix or isolate the Irvington Tunnel and the Alameda Siphons.

Users impacted:

The South Bay subsystem customers served off of the BDPLs remain isolated from the SFPUC system.

Water source:

The Harry Tracy WTP has ramped up to its maximum flow rate of 144 mgd. Demands on the system are assumed to remain high (300 mgd) as the system is utilized to fight fires and as leaks in the system are isolated and/or repaired. Of this demand, 144 mgd would be met from Harry Tracy WTP (reverse flow), and the remainder would be met from local storage along the Peninsula and in the City. (Pulgas Balancing Reservoir was assumed drained by this time period.)

Time 4: 24 hours to 20 days after the Hayward Fault event

System operations:

Assumptions were made of restoration times for the SFPUC to repair damaged facilities back to operational condition, at least on a temporary basis. The temporary restoration times assumed for the damaged SFPUC facilities in this scenario were described earlier in this TM No. 3.

Users impacted:

The Alameda Siphons, Irvington Tunnel and the BDPLs remain out of service. The South Bay subsystem customers served off of the BDPLs remain isolated from the SFPUC system. Because of the anticipated isolation of the South Bay subsystem, the Peninsula and City SFPUC customers' demands can reliably be met from via the Harry Tracy WTP, up to average day demand. However, if the BDPLs are less damaged than anticipated and the South Bay subsystem can be served by the SFPUC system, the demand of the system will quickly exceed the capacity of the SFPUC system to deliver water from the Harry Tracy WTP south to the Peninsula and South Bay subsystem customers. The Harry Tracy WTP continues operating up to its maximum capacity of 144 mgd (its current sustainable capacity for meeting all of the requirements of DHS, however, is estimated to be more like 114 mgd). Demands on the system are reduced, as the system customers become aware of the damage to the system and the isolation of two of its three water supplies. The demand of the system during this time was assumed to be 30 percent of average day demand or approximately 50 mgd for the Peninsula customers, and 50 percent of average day demand or approximately 40 mgd for City system customers.

Water source:

During this time period, 100% of the demand is met from the Peninsula watershed via the Harry Tracy WTP.

Time 5: 20 days to 30 days after the Hayward Fault event

System operations:

BDPL No. 3 is repaired and back in service. South Bay SFPUC customers served off of BDPL No. 3 can now be served from the Peninsula watershed supply via the Harry Tracy WTP. The remaining BDPLs, the Irvington Tunnel, and the Alameda Siphons remain out of service. The Harry Tracy WTP is treating water up to its capacity of 144 mgd. Demands on the system are ramping back up to average day, or approximately 236 mgd (not including those areas served by BDPL Nos. 1 & 2 only). Of the 236 mgd demand, 80 mgd is the CDD system and 155 mgd is the Peninsula and South Bay customers.

Users impacted:

There is adequate capacity in the SFPUC system to serve the northern peninsula and the City system close to average day demand. (The City system could be served up to its 80 mgd average day demand.) South Bay subsystem SFPUC customers served BDPLs Nos. 1 & 2 only, such as City of Hayward, East Palo Alto, Menlo Park and Skyline County Water District remain isolated from the SFPUC system. However, the Peninsula and South Bay customers would be limited to approximately 80 mgd (approximately 50 percent of its ADD) by the capacity of the Harry Tracy WTP and the capacity of the Crystal Springs pipeline. As a result, the Crystal Springs, San Andreas and South Bay subsystems would be required to reduce demands on their systems to approximately half of their average day demand.

The 80 mgd capacity of the Sunset and Crystal Springs pipelines via the Capuchino Valve Lot is a limitation for meeting the demands of the subsystems south of the Harry Tracy WTP for the 20 day to 30 days timeframe. It is possible that with demand reduction, up to 60 mgd could be delivered to the City system from Harry Tracy WTP, and the remaining 80 mgd could be delivered southward through the Sunset and Crystal Springs pipelines to Peninsula and South Bay customers. However, as mentioned previously, this is only adequate to meet about half of the average day demand of those subsystems.

Water source:

During this time period, 100% of the water supplied to the system continues to be from the Peninsula watersheds via the Harry Tracy WTP. This is a problem since there is only treatment and transmission capacity to deliver 80 of the 155 mgd demand to the areas south of the Harry Tracy WTP.

It has been assumed that at the start of the event response, the local watershed reservoirs were at 65% capacity.

Regional System Response
Time 6: 30 days after the Hayward Fault event

System operations:

BDPL No. 1 or No. 2 from Pulgas to Redwood City is back in service. (The remainder of BDPLs Nos. 1 and 2 between Redwood City and Newark remain out of service indefinitely.) The capacity of BDPLs at this point is approximately 110 mgd, as limited by the capacity of BDPL No. 3, however, delivery to this end of the system remains limited to the output of the Harry Tracy WTP. Irvington Tunnel remains out of service for up to another 30 days. Demands of the system are average day, or approximately 236 mgd (not including those areas served by BDPL Nos. 1 & 2 only).

Users impacted:

South Bay SFPUC customers served off of BDPL's are still being served by the Peninsula supplies (supplies east of Irvington remain inaccessible for up to 30 more days). SFPUC customers served off of BDPL Nos. 1 and 2 east of the Redwood City valve lot, including East Palo Alto, Menlo Park and customers served exclusively off of the Palo Alto Pipeline, remain isolated from the system.

Water sources:

The Irvington Tunnel remains out of service for up to 60 days after the event, which means that the South Bay and Peninsula SFPUC customers remain isolated from the Hetch Hetchy and/or Sunol Valley supplies. As mentioned previously, the Harry Tracy WTP is operational after 3 to 6 days. At time 6, 30 days after the event, the system continues to be served San Andreas Supply via the Harry Tracy Supply, however, Harry Tracy WTP does not have the capacity to meet the ADD of the City, Peninsula and South Bay customers. Once the Irvington Tunnel is back in service, up to day 60 following the event, the SFPUC system can be served by Hetch Hetchy and/or Sunol Valley supplies to meet its ADD.

4.3 Calaveras Fault Event Response

The following discussion presents a reconnaissance level time lapse response of the SFPUC system to magnitude 6.8 seismic event on the Calaveras Fault, which will in turn determine the reliability of the SFPUC system for this particular event.

Assumptions:

System demand is approximately average day demand or 260 mgd. This demand is being supplied from multiple SFPUC water supply sources including the following.

- 200 mgd from Hetch Hetchy
- 40 mgd from Calaveras via the Sunol Valley WTP
- 40 mgd from Crystal Springs via the Harry Tracy WTP

The excess flow from Hetch Hetchy and the Sunol Valley WTP typically spills to Crystal Springs Reservoir.

SFPUC system reservoirs are approximately two-thirds full at the time of the event.

Time 1: At the time of the Calaveras Fault event

System operations:

A magnitude 6.8 seismic event occurs on the Calaveras Fault. The BDPLs Nos. 3 & 4 experience the highest ground shaking with peak ground accelerations of 0.6 to 0.7g in South San Jose area. Facilities in the Sunol Valley will experience peak ground accelerations of 0.5 to 0.6g and 0.1 to 0.4g will be common in the rest of the South Bay and lower Peninsula.

Based on the Phase I Study results, the facilities listed in Table 14 would be highly vulnerable to this event and were assumed for this reconnaissance level evaluation to not be operational following the event. These facilities assumed to have failed are also shown on Figure 6.

Figure 14
Facilities Assumed to have failed following
A Magnitude 6.8 Seismic Event on the Calaveras Fault

San Antonio Pump Station
Sunol Valley WTP
Alameda Creek Siphons
Irvington Tunnel
San Antonio Dam and Outlet Towers
BDPLs Nos. 1 & 2
BDPLs Nos. 3 & 4

The system operations are impacted the same as with the Hayward fault event, including the fact that because of anticipated facilities failures, the Hetch Hetchy supply and Sunol Valley supply are isolated from the system and from SFPUC customers.

Time 2: Immediately after the Calaveras Fault event (1 to 2 hours)

System operations:

Valves at the East Portal or upstream in the Coast Range Tunnel are closed, shutting down the supply from Hetch Hetchy. Valves are also closed at the Alameda West Portal and at Irvington Portal isolating the Sunol Valley facilities from the SFPUC customers. On the west end of the SFPUC system, valves are shut off upstream of Pulgas Tunnel to isolate the BDPLs to assess the damage.

Users impacted:

The South Bay subsystem SFPUC customers served from BDPLs are isolated from the SFPUC system and dependant completely on local storage and alternative available water supplies.

Water source:

Water demand would be met with 40 mgd from Pulgas Balancing Reservoir, 40 mgd would be met from Harry Tracy WTP, and the remainder would be met from local storage in the Peninsula and City systems. Harry Tracy WTP would begin ramping up to its maximum flow rate, currently 144 mgd, which takes 4 to 6 hours.

Time 3: 2 to 24 hours after the Calaveras Fault event

System operations:

Crews are mobilized to assess the damaged BDPLs, concentrating primarily on the least vulnerable BDPL section. In addition, crews are mobilized to assess damage to the San Antonio Pump Station, Sunol Valley WTP, Calaveras Dam, Turner Dam, and associated pipelines.

Users impacted:

The South Bay subsystem customers served off of the BDPLs remain isolated from the SFPUC system

Water source:

The Harry Tracy WTP has ramped up to its maximum flow rate of 144 mgd and is back feeding to the South Bay. Pulgas Balancing Reservoir was assumed drained by this time period.

Time 4: 24 hours to 20 days after the Calaveras Fault event

System operations:

Assumptions were made of restoration times for the SFPUC to repair damaged facilities back to operational condition, at least on a temporary basis. The temporary restoration times assumed for the damaged SFPUC facilities in this scenario were similar to the temporary restoration times assumed for the Hayward Fault event evaluation and are presented above.

Users impacted:

The Alameda Siphons, Irvington Tunnel and the BDPLs remain out of service. The South Bay subsystem customers served off of the BDPLs remain isolated from the SFPUC system.

Water source:

The north Peninsula and City SFPUC customers' demands are met from the Harry Tracy WTP. The Harry Tracy WTP continues operating up to its maximum capacity of 144 mgd. Demands on the system are reduced, as the system customers become aware of the damage to the system and the isolation of two of the Hetch Hetchy supply. The demand of the system during this time was assumed to be 30 % of ADD or approximately 50 mgd for the Peninsula and City system customers. During this time period, the demand is met from the Peninsula watershed via the Harry Tracy WTP.

Time 5: 20 days to 30 days after the Calaveras Fault event

System operations:

The damaged BDPL No. 3 is repaired and back in service. South Bay SFPUC customers served off of BDPL No. 3 can now be served from the Peninsula watershed supply via the Harry Tracy WTP. The remaining BDPLs, the Irvington Tunnel, the Alameda Siphons, San Antonio Pump Station, and the Sunol Valley WTP remain out of service. The Harry Tracy WTP is treating water up to its capacity of 144 mgd.

Users impacted:

There is adequate capacity in the SFPUC system to serve the northern Peninsula and the City system close to average day demand. However, the south Peninsula and South Bay customers would be limited to approximately 80 mgd (approximately 50 % of its ADD) by the capacity of the Harry Tracy WTP and the capacity of the Crystal Springs pipeline.

Water source:

During this time period, water supplied to the unimpacted portion of the system continues to be from the Peninsula watersheds via the Harry Tracy WTP. This is a problem since there is only treatment and transmission capacity to deliver 80 of the 155 mgd demand to the areas south of the Harry Tracy WTP.

It has been assumed that at the start of the event response, the local watershed reservoirs were at 65% capacity.

Regional System Response
Time 6: 30 days after the Calaveras Fault event

The system operations, users impacted and water sources available are the same as with the Hayward fault event, including that because Irvington Tunnel is anticipated to be out of service for up to 60 days following the event, the Hetch Hetchy supply and the Sunol Valley supply are isolated from the system and from SFPUC customers.

System operations:

BDPL No. 1 or No. 2 from Pulgas to Redwood City is back in service. (The remainder of BDPLs Nos. 1 and 2 between Redwood City and Newark remain out of service indefinitely.) The capacity of BDPLs at this point is approximately 110 mgd, as limited by the capacity of BDPL No. 3, however, delivery to this end of the system remains limited to the output of the Harry Tracy WTP. Irvington Tunnel remains out of service for up to another 30 days. Demands of the system are average day, or approximately 236 mgd (not including those areas served by BDPL Nos. 1 & 2 only).

Users impacted:

South Bay SFPUC customers served off of BDPL's are still being served by the Peninsula supplies (supplies east of Irvington remain inaccessible for up to 30 more days). SFPUC customers served off of BDPL Nos. 1 and 2 east of the Redwood City valve lot, including East Palo Alto, Menlo Park and customers served exclusively off of the Palo Alto Pipeline, remain isolated from the system.

Water sources:

The Irvington Tunnel remains out of service for up to 60 days after the event, which means that the South Bay and Peninsula SFPUC customers remain isolated from the Hetch Hetchy and/or Sunol Valley supplies. As mentioned previously, the Harry Tracy WTP is operational after 3 to 6 days. At time 6, 30 days after the event, the system continues to be served San Andreas Supply via the Harry Tracy Supply, however, Harry Tracy WTP does not have the capacity to meet the ADD of the City, Peninsula and South Bay customers. Once the Irvington Tunnel is back in service, up to day 60 following the event, the SFPUC system can be served by Hetch Hetchy and/or Sunol Valley supplies to meet its ADD.

4.4 Great Valley Fault Zone Event Response

The following discussion presents a reconnaissance level time lapse response of the SFPUC system to magnitude 6.7 seismic event on the Great Valley Fault Zone, which will in turn determine the reliability of the SFPUC system for this particular event.

Time 1: At the time of the Great Valley Fault event

System operations:

A magnitude 6.7 seismic event occurs on the Great Valley Fault Zone. The SFPUC system facilities experience peak ground accelerations of 0.4g to 0.5g from approximately Vernalis to Mitchell Shaft, and 0.3 to 0.4g from Mitchell Shaft to the East Portal of the Coast Range Tunnel. The SFPUC facilities anticipated to be impacted include the San Joaquin Pipelines, the San Joaquin Valve House, Tesla Portal Valve House and Chlorination Station, and the Coast Range Tunnel.

Based on the Phase I Study results the facilities listed in Table 15 would be highly vulnerable to this event and were assumed for this reconnaissance level evaluation to not be operational following the event. These facilities assumed to have failed are also shown on Figure 7.

Table 15
Facilities Assumed to have failed following
A Magnitude 6.7 Seismic Event on the Great Valley Fault

San Joaquin Pipeline Nos. 1, 2, & 3
Tesla Portal Disinfection Station
Coast Range Tunnel
Thomas Shaft Disinfection Station

As can be seen from the table, damage is anticipated for the main transmission facilities from Hetch Hetchy. The western portion of the San Joaquin Pipelines fail either because of a partial or complete pipe and/or valve system failure. Water will begin spilling at Tesla Portal or at damaged sections of the San Joaquin pipeline near Tesla Portal. Water pressure in the system begins to drop. Tesla Portal chlorination facilities will experience intense ground shaking and could not be relied upon for service following a Great Valley Fault event. The Hetch Hetchy supply is essentially isolated from the SFPUC system.

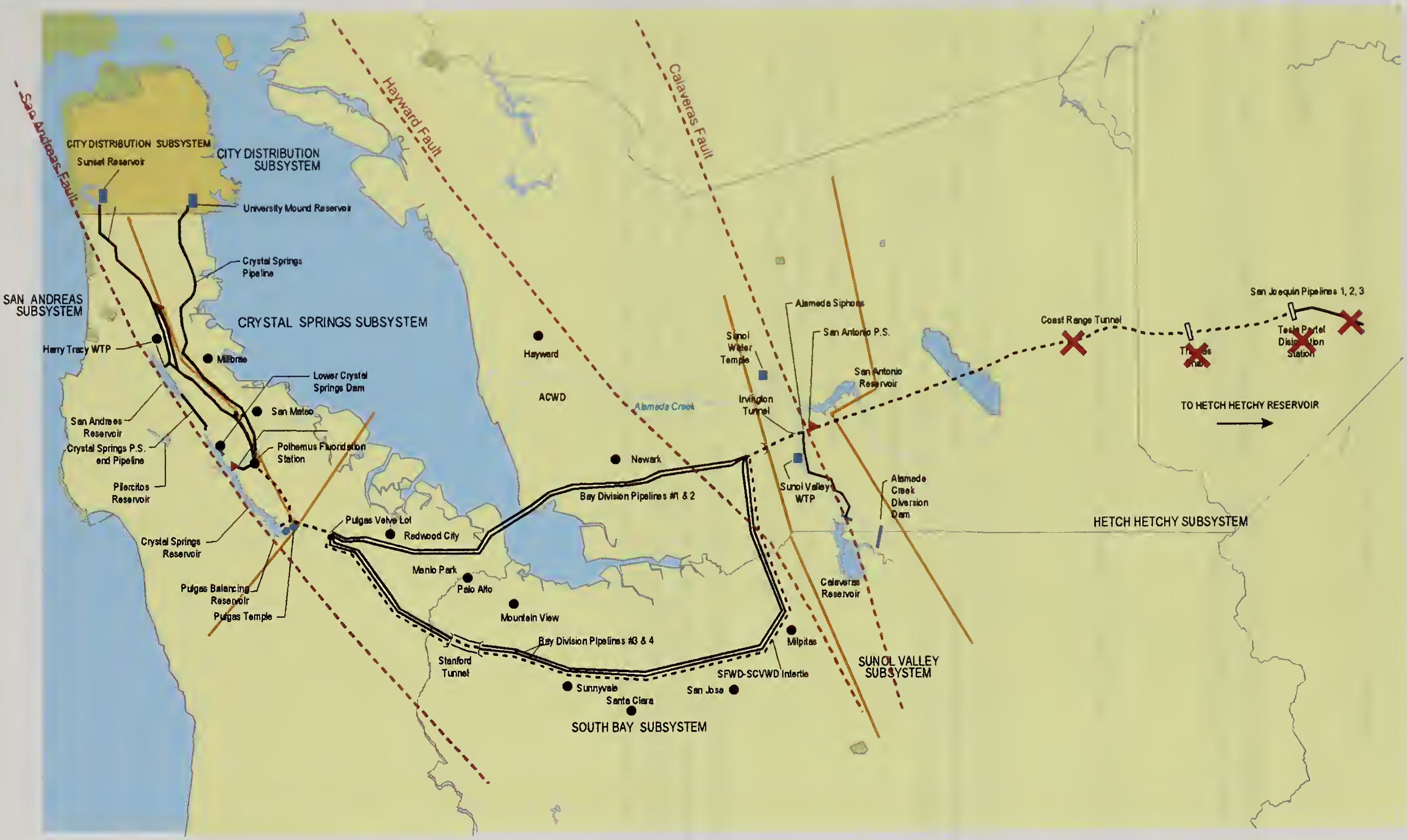


FIGURE **7**
Great Valley Fault Event Response
SFPUC Facilities Assumed to Fail

Time 2: Immediately after the Great Valley Fault event (1 to 2 hours)

System operations:

Hetch Hetchy water supply is shut at the San Joaquin valve house or further upstream. Valves are shut at the East portal of the Coast Range Tunnel. The damaged sections are now isolated.

Users impacted:

The majority of the SFPUC customers are not directly impacted by the Great Valley event.

Water source:

Because the majority of the SFPUC customers are outside the impacted areas of this event, system demand will remain at the ADD demand of 260 mgd. (In other scenarios demands in the first 24 hours were anticipated to approximately double the ADD because of fire fighting requirements and leaks in the system.) Water source will be:

- 40 mg from the Balancing Reservoir at Pulgas,
- Sunol Valley WTP (40 mgd initially; ramping up to 136 mgd)
- Harry Tracy WTP (40 mgd initially; ramping up to 144 mgd)

As can be seen from the listing of water sources, the SFPUC will only be capable of meeting approximately 120 mgd of the 260 mgd demand during this time period. The remainder of the demand must be met from local storage of the South Bay, Peninsula and City customer systems. It can be assumed that the supply could be available from the SCVWD intertie connection to the SFPUC system if required.

Time 3: ***2 to 24 hours after the Great Valley Fault event***

System operations:

There will be continued activities to isolate the damaged sections of the system. Crews will be dispatched to inspect the damage. The Sunol Valley and Harry Tracy WTPs will be ramping up their capacities.

Users impacted:

Same as for Time 2. Customers will continue to rely partially on local storage. Some amount water conservation may be necessary until the Sunol Valley and Harry Tracy WTPs are treating water at full capacity, which takes approximately 4 to 6 hours to achieve.

Water source:

The Harry Tracy WTP and the Sunol Valley WTP have ramped up to 144 mgd and 136 mgd, respectively. 144 mgd and 136 mgd are the current peak capacity ratings of these facilities. The demands of the system remain ADD, 260 mgd. Of this demand, the Sunol Valley supply via the Sunol Valley WTP serves the ADD needs of the South Bay subsystem, approximately 110 mgd; and the Peninsula supplies via the Harry Tracy WTP serve the ADD needs of the Peninsula and City systems, approximately 150 mgd (80 mgd to the City and 70 mgd to the Peninsula).

Time 4: 24 hours to 20 days after the Great Valley Fault event

System operations:

Assumptions were made of restoration times for the SFPUC to repair damaged facilities back to operational condition, as least on a temporary basis. The temporary restoration times assumed for the damaged facilities in this scenario are presented above.

Users impacted:

Same as for Time 2.

Water source:

Same as for Time 2. The average day demand of 260 mgd is being supplied as follows:

• Sunol Valley supplies via Sunol Valley WTP	136 mgd
• Peninsula supplies via Harry Tracy WTP	144 mgd
• Potentially SCVWD intertie	40 mgd

Any combination of these sources would be available to meet the demands of the system. It should be noted that the use of the SCVWD intertie was considered available at this time under this scenario because the SCVWD system is not anticipated to be impacted by an event on the Great Valley Fault. However, it was agreed that for all the other scenarios evaluated the SFPUC system could not rely on the use of the SCVWD intertie because those events that impact the SFPUC system will also likely greatly impact the SCVWD system. This important assumption will be evaluated further in the next phase of the study.

Time 5: 20 days to 30 days after the Great Valley Fault event

System operations:

Based on the assumed restoration times indicated above, the damaged facilities are not yet repaired.

Users impacted:

Same as for Time 2.

Water source:

During this time period, 100% of the water supplied to the system continues to be from the local watersheds via the Harry Tracy and Sunol Valley WTPs. It has been assumed that at the start of the event response, the local watershed reservoirs were at 65% capacity.

With these assumptions, water supply availability is not an issue for this scenario, so long as the infrastructure is available to deliver the supply.

Time 6: 30 days after the Great Valley Fault event

System operations:

Based on the assumed restoration times, the Coast Range Tunnel remains out of service for up to an additional 30 days (up to 60 days following the event). The SFPUC system is served from Sunol Valley and Peninsula supplies.

Users impacted:

Same as for Time 2.

Water source:

During this time period, 100% of the water supplied to the system continues to be from the local watersheds via the Harry Tracy and Sunol Valley WTPs until such time as the Coast Range Tunnel is repaired and brought back into service. Upon repair of the Coast Range Tunnel, Hetch Hetchy supply would be accessible to SFPUC customers.

4.5 Baseline Reliability Findings

4.5.1 Regional Facilities

San Andreas Fault Event

In the time period from 24 hour to 20 days, the SFPUC system is largely out of service. The primary concern is the isolation of most of the South Bay subsystem customers, and the Peninsula and City subsystem customers, from the SFPUC supplies. During this time period, the backbone transmission facilities will be identified based on 1) the serviceability of existing pipelines, and 2) the ability to repair damaged pipelines connected to the operational pipelines. At the very least, the backbone transmission facilities will include:

Backbone Transmission Facilities following
A Magnitude 7.9 Seismic Event on the San Andreas Fault

BDPL No. 3
BDPL No. 2 to Ravenswood Valve Lot
Pulgas Tunnel and Valve Lot
Crystal Springs Bypass Tunnel and Pipeline
Crystal Springs Pipeline No. 2 or Sunset Supply Pipeline to Baden Pump Station
San Andreas Reservoir Adit 2 or 3
San Andreas Reservoir RW 2 or 3
Harry Tracy WTP
San Andreas Pipelines No. 2 or 3
San Andreas Pipeline No. 2 or Sunset Supply Line from Baden PS to Sunset Reservoir
University Mound Feeder Mains
Lake Merced Pump Station only if Sunset Supply Line is utilized

Having these facilities available would allow the system to be served from Hetch Hetchy and/or Sunol Valley supplies via BDPL No. 3.

In the time period up to 30 days, the SFPUC system north of Pulgas remains largely out of service. There is adequate infrastructure capacity to meet the demands of the South Bay subsystem customers from Hetch Hetchy and/or the Sunol Valley supply via BDPL No. 3. The limitations for getting the Peninsula and City subsystems back into service at 30 days are:

- The Pulgas Tunnel remains out of service, which limits the ability to deliver water north of Pulgas from Hetch Hetchy and/or the Sunol Valley supplies.

- Although the Harry Tracy WTP is at least partially operational, one of the adits, one of the San Andreas raw water pipelines, and either San Andreas Pipeline No. 2 or 3 still need to be stored to at least partial capacity service.

- The major transmission pipelines along the Peninsula such as either the Crystal Springs No. 2 or the Sunset Supply Line, and the major transmission pipelines into the City system such as either San Andreas No. 2 or the Sunset Supply Line, still need to be restored to at least partial capacity service.

In the period after 30 days, there remains a few South Bay subsystem customers isolated from the SFPUC system, including East Palo Alto, Menlo Park and customers served off of the Palo Alto Pipeline. There is adequate infrastructure capacity (approximately 110 mgd) to meet the demands of the remainder of the South Bay subsystem customers from Hetch Hetchy and/or the Sunol Valley supply via BDPL No. 3. The SFPUC system north of Pulgas can now be served by San Andreas supplies via the Harry Tracy WTP. There is adequate treatment capacity from Harry Tracy WTP and infrastructure capacity in the pipelines serving to the south and north of the Harry Tracy WTP to meet the demands of the City system and the SFPUC customers north of Pulgas.

The limitations for getting the remaining SFPUC customers back in service after 30 days are:

- Repair of BDPL No. 1 or No. 2 between the Redwood City Valve Lot and Ravenswood Valve Lot, and

- Restoration of one of the Crystal Springs adits, the Crystal Springs Pump Station, and the Crystal Springs San Andreas pipeline or repair of the Pulgas Tunnel and the Crystal Springs Bypass Tunnel. This is important because San Andreas Reservoir capacity (assumed to be two-thirds full at the beginning of the event) can by itself only sustain ADD (140 to 150 mgd) supply to the SFPUC Peninsula and City customers for 25 to 30 days. Restoration of the Crystal Springs facilities would allow water to be transferred from Crystal Springs Reservoir to San Andreas Reservoir. Repair of the tunnels would allow a portion of the demand of the Peninsula and City systems to be met by Hetch Hetchy and/or the Sunol Valley supply.

Because of the estimated severe accelerations and liquefaction potential in the vicinity of the BDPL Nos. 1 and 2, it is uncertain how long it would take to provide service through BDPL No. 1 or No. 2 between Redwood City Valve Lot and Ravenswood Valve Lot. However, it is anticipated that options are available to get service to the isolated customers, maybe through an emergency connection of the Palo Alto Pipeline to BDPL No. 3, to restore service within 60 days.

The next priority would be to get the Crystal Springs Pump Station and Crystal Springs San Andreas Pipeline into service before 30 days to maximize the supply available from the Peninsula watershed via the Harry Tracy WTP.

Finally, it is anticipated that the Pulgas Tunnel and the Crystal Springs Bypass Tunnel would be restored to at least partial service in up to 60 days. If this is possible, this would be the next highest priority to getting treated water to the isolated South Bay subsystem customers.

Hayward Fault Event

In the time period from 24 hour to 20 days, the anticipated isolation of the South Bay subsystem will allow the Peninsula and City SFPUC customers' demands to be met from via the Harry Tracy WTP. The Harry Tracy WTP continues operating up to its maximum capacity of 144 mgd (its current sustainable capacity for meeting all of the requirements of DHS, however, is estimated to be more like 114 mgd). Demands on the system are reduced, as the system customers become aware of the damage to the system and the isolation of two of its three water supplies. The demand of the system during this time was assumed to be 30 percent of average day demand or approximately 50 mgd for the Peninsula and City system customers. During this time period, 100% of the demand is met from the Peninsula watershed via the Harry Tracy WTP. The local storage reservoirs would be utilized to meet daily peaking requirements.

For the time period from 20 days to 30 days, water supply availability is not an issue for this scenario, so long as the infrastructure is available to support the supply. However, there are four limitations of the system for optimizing the use of these available Peninsula watershed supplies. They are:

- The capacity of the Crystal Springs Pumping Station and Pipeline, which transfers raw water from Crystal Springs Reservoir to San Andreas Reservoir, is limited to approximately 70 mgd,
- The capacity of the Harry Tracy WTP is limited to 144 mgd, which is not adequate to meet average day demand of the SFPUC system should the system be isolated from Hetch Hetchy and Alameda watersheds.
- The conveyance of water from the Harry Tracy WTP south to the Peninsula is limited to 80 mgd by the Capuchino Valve Lot pressure reducing valve and the capacity of the Sunset and Crystal Springs pipelines, and
- The pressure capability of the Pulgas Tunnel.

The transfer capacity of the Crystal Springs Pump Station and Pipeline is not an issue for this time period. There is adequate storage in San Andreas Reservoir the meet the demands of the system through 30 days.

The 80 mgd capacity of the Sunset and Crystal Springs pipelines via the Capuchino Valve Lot is a limitation for meeting the demands of the subsystems south of the Harry Tracy WTP for the 20 day to 30 days timeframe. It is possible that with demand reduction, up to 60 mgd could be delivered to the City system from Harry Tracy WTP, and the remaining 80 mgd could be delivered southward through the Sunset and Crystal

Springs pipelines to Peninsula and South Bay customers. However, as mentioned previously, this is only adequate to meet about half of the average day demand of those subsystems.

The elevation of the Pulgas weir will limit the pressures delivered to the areas south of Pulgas to below elevation 303 feet. The head required to push water from the Peninsula all the way back to the Irvington Tunnel is approximately elevation 317 feet. However, it appears that the elevation of connections to the SFPUC customers on the eastern side of the BDPLs, ACWD, are below elevation 303 and would still receive service.

Calaveras Fault Event

The critical facilities are the same as with the Hayward event scenario, i.e. the capacity of the Crystal Springs Pumping Station and Pipeline, the capacity of the Harry Tracy WTP, the conveyance capacity from the Harry Tracy WTP south to the Peninsula, and the pressure capacity of the Pulgas Tunnel. As a result, the flow implications of the Calaveras Fault event scenario during this time period are also similar to those of the Hayward fault event, as summarized below.

1. The Peninsula and South Bay customers may be required to reduce their demand for longer than originally anticipated by the proposed system demand requirements (refer to assumptions of TM No. 2). Without an alternative source of water, the reduced demand requirement may be as much as 50 to 60% of ADD.

2. The SFPUC would need to utilize an alternative source of treated water to serve its customers, up to 100 mgd.

After 20 days when the SFPUC system demands were anticipated to begin to recover back to average day demand (265 mgd), the existing SFPUC system cannot meet the needs of the Peninsula and South Bay customers. The limitations for meeting these demands are the capacity of the Harry Tracy WTP (even at its improved sustained capacity of 160 mgd) and the capacity of the Sunset and Crystal Springs pipelines used to transport water “south” to these customers.

In addition, the transfer capacity between Crystal Springs and San Andreas Reservoirs via the Crystal Springs Pumping Station (80 mgd), would limit the watershed supply to 60 to 70 days of useable storage (assuming the reservoirs start out at 65% capacity and the system demands are reduced to 114 mgd for 0 to 20 days, and 160 mgd for beyond 20 days).

As a result, it can be concluded that the Peninsula system by itself cannot meet the needs of the SFPUC system beyond 20 days, given the system flow requirements. Additional sources of treated water are required at 20 days. The length of time these additional sources are required would be dependent on the response capability of the SFPUC for repairing or bypassing the Irvington Tunnel.

Great Valley Fault Zone Event

It will be critical that the damage is isolated to the Great Valley fault zone area. All the facilities west of Coast Range Tunnel need to remain operational. In addition, two limitations of critical facilities of the system need to be addressed.

1. The capacity of the Crystal Springs Pumping Station and Pipeline, which transfers raw water from Crystal Springs Reservoir to San Andreas Reservoir, is limited to approximately 70 mgd.

2. The capacity of the Harry Tracy WTP is limited to 144 mgd, and the current capacity of the Sunol Valley WTP is 136 mgd. It is not certain whether these capacities can be sustained over a long period of time, beyond say 30 days.

The transfer capacity of the Crystal Springs Pump Station and pipeline is not an issue for this time period, through 30 days, however, this will be a limitation after approximately 60 days, assuming the Harry Tracy WTP continues to operate at its maximum capacity of 144 mgd. As a result, if the Coast Range Tunnel cannot be in service in 60 days, the Peninsula and City customers will be required to conserve (reduce demands), or additional transfer capacity will be required, or other treated water supplies will be required.

The current sustained capacity of the Harry Tracy WTP and the Sunol Valley WTP is estimated to be 114 mgd and 109 mgd, respectively. It has been assumed for the purposes of this evaluation that the treatment plants would operate at their current maximum rated capacity of 144 mgd and 136 mgd. If it is determined that the treatment plants can not operate for a sustained period of time at these rated capacities, the SFPUC system will not be capable of meeting the ADD of the system. Other local supplies or conservation will be required.

Summary of Regional Facilities Reliability

As can be concluded from the hazard event response scenarios, the SFPUC system cannot be relied upon to meet the water supply needs of many of its customers following a number of major seismic events. The limitation for meeting these demands is generally access to adequate treated water supplies due to failed transmission facilities. It is clear that improving the seismic reliability of a number of these facilities would provide a "hardened" backbone system that would improve the reliability of the overall SFPUC system.

The following table lists some of the projects which have been identified based on the analyses described herein. This list is not yet complete, as additional facility evaluations are on-going. A complete list of recommended studies and improvements will be included in TM No. 4.

Preliminary Recommendations

Weak Link	Recommendation
BDPL Nos. 1 & 2	• Replace with BDPL No. 5
BDPL No. 3	• Highest priority improvement, requires improving its reliability to survive PGAs of 0.6 to 0.8g
Harry Tracy WTP	• Ensure that Harry Tracy WTP can structurally withstand event and meet minimum levels of treatment • Test and ensure that Harry Tracy WTP can backfeed as far east as Newark assuming Pulgas Tunnel pressure impact is resolved • Increase the sustained capacity to assure a minimum reliable capacity of 160 mgd
Crystal Springs Pipeline No. 2	• Improve the reliability of this pipeline to survive PGAs of 0.5 to 0.6g in high liquefaction zones
Crystal Springs Bypass Pipeline	• Improve the reliability of this pipeline to survive PGAs of 0.5 to 0.6g in high liquefaction zones
San Andreas Pipeline No. 2	• Improve the reliability of this pipeline to survive PGAs of 0.5 to 0.6g
South Bay Customer Connections	• Provide cross-connections between BDPL Nos. 1 & 2 and 3 & 4 to allow for valving and routing of supply around breaks • Provide connections of South Bay Customers to BDPL No. 3, beginning with the Palo Alto Pipeline
Capuchino Valve Lot	• Increase the capacity of the Capuchino PRV to allow more than 80 mgd to be served to the Peninsula and South Bay customers from Harry Tracy WTP
Irvington Portal	• Increase the reliability of the tunnel portals to survive PGAs of 0.6 to 0.7g or prepare an emergency response to temporarily repair the portals in 30 to 60 days.
Crystal Springs Pump Station & Crystal Springs San Andreas Pipeline	• Increase the capacity of the pump station and pipeline to increase the ability to transfer more than 70 mgd from Crystal Springs to San Andreas Reservoir
Pulgas Tunnel	• Increase the pressure capacity of Pulgas Tunnel to provide flexibility to serve the South Bay customers all the way back to Newark from the Harry Tracy WTP
SCVWD Intertie	• Complete the SCVWD intertie to provide a potential emergency source of treated water to the SFPUC system (40 mgd)
Parallel pipeline to Pulgas/Crystal Springs Tunnels	• Consider a new project to provide a parallel pipeline to the Pulgas Tunnel and Crystal Springs Bypass Tunnel and Pipeline to provide a second transmission path for this portion of the system
Alameda Siphons and San Joaquin Pipelines	• Must be able to withstand all events or result in minor repairs so that when supply can be delivered, it is available. May result in new San Joaquin Pipeline and/or new siphons.
All critical facilities	• Conduct seismic assessments of critical facilities first, followed by all other significant facilities
All critical pipelines	• A pipeline prioritization repair plan is needed to aid in responding to an emergency. This plan should include the backbone facilities described above. Having a prioritized plan ensures that the more critical parts of the distribution system can be used when the SFPUC regional supply becomes available. • Review the capital improvement projects identified for the next five years and consider the purchase of materials (e.g., pipes, pumps) for these projects. These materials could be stored and used during an emergency.

4.5.2 CDD Facilities

As a result of the above time sequence analysis for the San Andreas event, it can be concluded that the CDD can not meet its system needs beyond three days. It is anticipated that the system will be completely without water from day 3 to day 30. This is due to damage anticipated to the Peninsula pipelines supplying the CDD and the lack of storage available within the system. In addition to the overall need for more potable water storage, the following conclusions regarding critical facilities and the overall CDD system reliability can be made.

- Storage is needed primarily in the northern part of the City. Consider rebuilding Francisco Reservoir at a higher elevation or adding storage near the Presidio, in addition to implementing the planned Balboa Reservoir construction. This additional storage will increase the number of days of supply, but will still not meet a significant portion of the system demands between day 3 and day 30.

- The reinforcement of the roofs of Sunset, University Mound, College Hill, and Summit reservoirs is important in maintaining the potable quality of water in as much of the distribution system as possible.

- If Lake Merced could be connected to the system within two days, this supply would greatly increase the reliability of the system. A minimum level of treatment should be provided (e.g., disinfectant) to maintain the potable quality of water in as much of the distribution system as possible. Investigations should be made in Phase III to consider permanent or standby treatment capacity for this Lake Merced supply and the construction of a new intake at a lower elevation than the existing intake.

- Developing additional groundwater supplies, as described in the 1996 *San Francisco Groundwater Master Plan*, could increase the reliability of the system in areas surrounding these new or increased capacity wells following an event.

- The primary pipelines linking the CDD to the SFPUC Regional System (Crystal Springs, Sunset, Baden-Merced, and San Andreas) are the highest priority for system restoration following an event.

- The Crystal Springs Pipeline No. 1 is a critical facility for the University Mound pressure zone (eastern part of the City). The bypass should be constructed and the pipeline returned to operation as soon as possible.

- A backbone system for the larger pressure zones (e.g., Sunset, University Mound, College Hill) should be identified which will not only increase the availability of flow between the east and west pressure zones, but would also reduce repair times following an event by providing strengthened facilities. The backbone system requires either replacing existing older pipes, or adding new facilities which also provide some redundancy, both to and from the primary reservoirs.

An example of how a backbone system can increase reliability, can be found within the Sunset pressure zone. The existing 60-inch pipeline from Sunset Reservoir could be replaced with new pipelines and extended to the northern part of the pressure zone with an emergency connection (PRVs, etc.) to the northern University Mound pressure zone. An alternate backbone is available by purchasing the abandoned Lake Honda Tunnel under Forest Hill Lodge and adding an extension from the existing San Andreas Pipeline No. 2 to this tunnel. The alignment could be routed to the northern part of the Sunset pressure zone to a new reservoir which would provide an emergency supply for the northern part of the University Mound pressure zone. This backbone system could then be used in an emergency to serve the most vulnerable part of the system (north University Mound), and it becomes a priority conveyance facility to repair immediately following an event. These alternative backbone alignments should be compared for levels of reliability and cost effectiveness during Phase III.

- Because of the extensive damage anticipated for a San Andreas event of this magnitude, a pipeline prioritization repair plan is needed for the CDD facilities, to aid in responding to an emergency. This plan should include the backbone facilities described above, plus primary connections between the various pressure zones. For example, for the western part of the city, the pipelines between Sunset, Sutro, and Summit reservoirs should be a high priority for repair. Having a prioritized plan ensures that the more critical parts of the distribution system can be used when the SFPUC regional supply becomes available.

- The City is currently replacing exposed portions of the pipelines from University Mound. A new backbone pipeline for this pressure zone should be considered. It should be routed around the liquefaction zones to the extent possible, and have repair materials stockpiled near the unavoidable liquefaction zones.

- Review the capital improvement projects identified for the next five years and consider the purchase of materials (e.g., pipes, pumps) for these projects. These materials could be stored and used during an emergency.

- Prearrange for contractors to be available for emergency assistance. These contractors would include minority- and women-owned businesses within the City.

Seismic assessments of all reservoirs and pump stations are being conducted or are planned to be conducted. These condition assessments are critical to a better understanding of the vulnerability of the facilities under a 7.9 San Andreas event. The results of these assessments are also needed for the Phase III analysis.

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT: Technical Memorandum No. 3
Appendix A: Facility Linkages and Functional/Operational Relationships

PREPARED BY: The Water Reliability Partnership

DATE: July 13, 1999

1.0 INTRODUCTION

The Phase I Facility Assessment undertook the assessment of all water storage, transmission and treatment facilities, as well as power generation and transmission facilities, operated by the SFPUC. The study was designed to determine the criticality of each facility to the mission of the SFPUC and to perform a preliminary assessment of each facility's potential vulnerability to damage or failure from a variety of physical hazards or events. The Phase I Facility Assessment focused on individual facilities, assessing for each the:

- Degree of risk to the facility from each potential event;
- Likelihood of complete or partial failure from each potential event;
- Magnitude of potential adverse impacts resulting from the most likely failure scenario; and
- Operational flexibility in the event of facility failure.

Two issues remaining to be addressed in the Phase II scoping phase are:

1. Assessment of the susceptibility of a clustered group of facilities to failure from a single event or the simultaneous failure of adjacent facilities in the system; and
2. Assessment of the criticality of facilities which must remain operational when other key facilities fail.

This technical memorandum summarizes the linkages by common hazard types, location or operational relationship and establishes the key facilities which must survive and form the backbone of the SFPUC water supply system.

2.0 FACILITY LINKAGE APPROACH

The linkage of SFPUC's facilities can be accomplished by location; type of hazard and operational and functional relationship. The types of hazards presented previously in TM No. 1: Hazard Events and Maps are generally classified into two categories:

- **Regional hazards** likely to cause widespread damage to large areas and multiple facilities such as earthquake, fire and power outage.
- **Localized hazards** likely to be isolated events with only localized damage to individual facilities, such as landslide, wear and tear (age), malicious act, and flood (in the case of flooding of water supply facilities).

To establish linkages among facilities, critical facilities as identified in Phase I study were re-evaluated by the construction of a facilities functional relationship chart (Exhibit 1). The chart is meant to be used only as a simplified tool to assess the cause and effect if a critical facility should fail.

In Exhibit 1, all critical facilities identified in the Phase I study are listed following the flow of water from O'Shaughnessy Dam to CDD. Each facility is assumed to fail as an independent incident. All facilities which fail to function as a result of the assumed failure and all facilities which must survive to deliver water to customers are marked to allow a qualitative assessment in terms of their likelihood of not functioning and the relative importance of their need to survive. As the SFPUC system is designed to have multiple work-around capability in most parts of the system, facilities which most frequently need to remain in operation can be identified and can be considered as the backbone system. As the work-around scenario may change over time and as improvements are being made to various parts of the system, the chart will need to be revised to reflect the status quo of the water supply system.

The relationship chart is constructed as follows:

1. Critical facilities of the SFPUC system as identified in the Phase I study from CDD to O'Shaughnessy Dam are identified under Line 1. They are listed following the flow of water from east to west under the following subsystems:

    - CDD Westside
    - CDD Eastside
    - WS&TD Peninsula
    - WS&TD South Bay
    - WS&TD Sunol Valley
    - HHW&P Facilities

    To establish a linkage, each facility under Column 1 is assumed to fail independently of other facilities due to an unspecified hazard event. The operational/ functional relationships with other critical facilities were established along the line of failed facility in two ways:

- Those facilities which will be rendered inoperable or cannot function as designed because of the failed facility.

- Those facilities which remain operational to deliver water to customers and meet the desired performance level.

2. The impact on service areas when a facility is assumed to fail (listed under Column 2) was assessed based on the consultant team's understanding of SFPUC operations and review by SFPUC operations staff. Service area impact is either shown as a complete outage or, if supply can be maintained at some level, as a partial outage. Service areas follow these six delineations:

   - CDD Westside
   - CDD Eastside
   - WS&TD Peninsula (North of Pulgas)
   - WS&TD South Bay (South of Pulgas)
   - Sunol Valley area
   - Up Country services

The assessment process is as follows:

1. Assume one facility in Column 1 fails completely due to a hazardous event.

2. Assess the impact on service if the outage caused by the facility failure is a complete outage, partial outage or no impact.

3. Assess the functionality or operability of each facility listed from O'Shaughnessy Dam to the CDD Facilities along the failed facility line to determine whether each facility:

   a. Will fail to operate/function as the result of the assumed failed facility.

   b. Must remain operational to provide redundancy so that the system can deliver water to its customers.

   c. Is not functionally linked with the failed facility and is not affected.

4. Repeat this process until each facility has been assumed to fail and the functional relationship is independently assessed on a facility-by-facility basis.

5. Results are shown on Exhibit 1. An example of the evaluation of operational relationship follows. This example shows the evaluation assuming the Alameda Siphons have failed.

   Example: ***All three Alameda Siphons are damaged by a Calaveras Fault Event and must be shut down for repair. The Hetch Hetchy supply is lost, the aqueduct is closed at the Sunol Valley and west to Irvington Tunnel due to failure of the siphons. The chart assumes partial customer impacts in the City, on the Peninsula and in the South Bay because local supplies are available in the Peninsula subsystem and Harry Tracy WTP is operational.***

Partial service is at low pressure and significantly reduced deliveries. System is assumed to operate with reverse flow from Harry Tracy WTP to serve SFPUC customers south of Pulgas.

Step 1: *Find the Alameda Siphon under Line 1, follow the Alameda Siphon line horizontally to the right and mark Alameda Siphon as failed (refer to legend on Exhibit 1 for proper symbol to use)*

Step 2: *Under Column 2, identify the areas impacted by the outage of the Alameda Siphons. In this case, all WS&TD and CDD service areas are impacted. Mark WS&TD North of Pulgas, WS&TD South of Pulgas, CDD Eastside and CDD Westside as partially impacted as water supply is still available from Harry Tracy Water Treatment Plant.*

Step 3: *Assess the impact on individual facilities from O'Shaughnessy Dam downstream to CDD along the Alameda Siphon horizontal line.*

1. *Identify and mark all facilities that fail to function as a result of the outage of the Alameda Siphons:.*

    - *Irvington Tunnel*
    - *Sunol Valley Water Treatment Plant*
    - *San Antonio Reservoir*
    - *San Antonio Pump Station*
    - *Calaveras Dam/Reservoir*
    - *Coast Range Tunnel*
    - *Tesla Portal Disinfection Station*
    - *San Joaquin Pipelines No. 1, 2 and 3*
    - *Roselle Crossing*
    - *Rock River Lime Plant*
    - *Foothill Tunnel*
    - *Priest Dam, Reservoir, Outlet and Tunnel*
    - *Mountain Tunnel*
    - *Canyon Power Tunnel*
    - *O'Shaughnessy Dam*

2. *Identify facilities along Line 1 which must remain operational to maintain service:*

    Regional Facilities:

    - *Bay Division Pipelines Nos. 3 and 4*
    - *Bay Division Pipelines Nos. 1 and 2 (end sections)*
    - *Pulgas Balancing Reservoir/Pump Station*
    - *Pulgas Tunnel/Valve Lot*
    - *Crystal Springs Reservoir (Upper and Lower)*
    - *Crystal Springs Bypass Pipeline/Tunnel*
    - *Crystal Springs Pump Station*
    - *Pilarcitos Dam/Reservoir*
    - *Crystal Springs Pipeline No. 2*
    - *Crystal Springs/San Andreas Pipeline*
    - *San Andreas Reservoir*
    - *Harry Tracy Water Treatment Plant*
    - *Capuchino Valve Lot*
    - *Sunset Supply Line*

- *University Mound Reservoir*
- *Sunset Reservoir*
- *Lake Merced Pump Station*

CDD Facilities:

- *Cross Town Pipeline*
- *Bay Bridge Pump Station*
- *College Hill Reservoir/Feeder Main*
- *McLaren Pump Station/Tanks*
- *Sutro Reservoir/Feeder Main*
- *Summit Reservoir/Feeder Main*
- *Summit Pump Station*
- *Merced Manor Reservoir*
- *Central Pump Station*
- *Stanford Heights Reservoir/Feeder Main*
- *Potrero Heights Pump Station*

3.0 FINDINGS OF FUNCTIONAL/OPERATIONAL EVALUATION

The findings of the functional/operational evaluation are presented below.

1. Many facilities are required to remain operational under the failure mode of other facilities. Critical facilities which must remain operational most frequently to ensure service and delivery are considered as key facilities which form the backbone system to supply water to SFPUC customers.

CDD Facilities:

- Potrero Heights Pump Station
- Stanford Heights Reservoir and Feeder Main
- Central Pump Station
- Merced Manor Reservoir and Feeder Main
- Summit Pump Station
- Summit Reservoir and Feeder Main
- Sutro Reservoir and Feeder Main
- Lake Merced Pump Station
- Sunset Reservoir and Feeder Main
- McLaren Pump Station and Tanks
- College Hill Reservoir and Feeder Main
- Bay Bridge Pump Station[1]
- Cross Town Pipeline[1]
- Alemany Pump Station
- University Mound Reservoir and Feeder Main

WS&TD Facilities:

- Sunset Supply Line[1]
- San Pedro Valve Lot
- Baden Pump Station and Valve Lot
- Capuchino Valve Lot
- Harry Tracy Water Treatment Plant
- San Andreas Reservoir
- Pilarcitos Dam and Reservoir
- Crystal Springs/San Andreas Pipeline
- Crystal Springs Pump Station
- Crystal Springs Reservoir (Upper and Lower)
- Crystal Springs Pipeline No. 2
- Crystal Springs Bypass Tunnel and Pipeline
- Pulgas Tunnel and Valve Lot
- Pulgas Balancing Reservoir and Pump Station
- Bay Division Pipelines Nos. 1 & 2 (end sections)
- Bay Division Pipelines Nos. 3 & 4
- Irvington Tunnel
- Alameda Creek Siphons

---

[1] Facilities not considered critical in the Phase I study.

- Sunol Valley Water Treatment Plant
- San Antonio (Turner) Dam
- San Antonio Pump Station[1]
- Calaveras Dam

Hetch Hetchy Water & Power Facilities:

- Coast Range Tunnel/Tesla Portal
- Tesla Portal Disinfection Station
- San Joaquin Pipelines Nos. 1, 2 and 3
- Roselle Crossing[1]
- Foothill Tunnel/Red Mountain Bar Siphon
- Priest Dam, Reservoir, Outlet & Tunnel
- Mountain Tunnel/South Fork Crossing
- Canyon Power Tunnel
- O'Shaughnessy Dam

2. One way that the relative criticality of these key facilities can be qualitatively established is by assessing the need to remain operational during hazard events when a key facility fails. The following tabulation shows each facility and the frequency with which it must remain operational; those facilities with higher frequencies can be considered to be relatively more critical than those with lower frequencies. Relative criticality could also be measured by evaluating the service area impacted by the failure of each facility.

Facility	Frequency of "Must Remain Operational" when a key facility fails
CDD Facilities[2]:	
Potrero Heights Pump Station	49
Central Pump Station	49
Merced Manor Reservoir	49
Summit Pump Station	49
Lake Merced Pump Station	49
Sunset Reservoir Feeder Main/Reservoirs	49
McLaren Pump Station/Tanks	49
College Hill Reservoir Feeder Main	49
Bay Bridge Pump Station	49
University Mound Feeder Mains	49
Stanford Heights Reservoir/Feeder Main	48
Summit Reservoir/Feeder Main	48
Sutro Reservoir/Feeder Main	48
Cross Town Pipeline	18
Alemany Pump Station	15

---

[1] Facilities not considered critical in the Phase I study.

[2] CDD Facilities shown in italics are part of the CDD retail system.

Facility	Frequency of "Must Remain Operational" when a key facility fails
WS&TD Facilities:	
Bay Division Pipelines Nos. 1 & 2 (end sections)	44
Bay Division Pipelines Nos. 3 & 4	44
Irvington Tunnel	43
Alameda Creek Siphon Nos. 1, 2 and 3	43
Pulgas Tunnel/Valve Lot	43
Crystal Springs Pipeline No. 2	24
Pulgas Balancing Reservoir/Pump Station	24
Sunset Supply Line (North of San Pedro)	21
Harry Tracy Water Treatment Plant	18
San Andreas Reservoir	18
Crystal Springs/San Andreas Pipeline	18
Crystal Springs Pump Station	18
Crystal Springs Reservoir (Upper and Lower)	18
Sunol Valley Water Treatment Plant	10
San Antonio Pump Station	10
Crystal Springs Bypass Pipeline	9
Calaveras Dam	9
San Pedro Valve Lot	8
Capuchino Valve Lot	8
San Antonio Dam	8
Baden Pump Station and Valve Lot	5
Pilarcitos Dam/Reservoir	3
HHW&P Facilities:	
Tesla Portal/Coast Range Tunnel	10
Tesla Portal Disinfection Station	10
San Joaquin Pipelines Nos. 1, 2 and 3	10
Roselle Crossing	10
Foothill Tunnel/ Red Mountain Bar Siphon	10
Priest Reservoir and Dam	10
Mountain Tunnel/South Fork Crossing	10
Canyon Power Tunnel	9
O'Shaughnessy Dam	8

3. Multiple facility failures resulting from a single hazard event or multiple hazard events may be assessed by combining the single failure scenarios shown in Exhibit 1. The key facilities functional/operational chart may be used as a tool to facilitate evaluation of overall system operability under multiple failure scenarios from a regional disaster such as the Hayward Fault and/or San Andreas Fault seismic events.

	LINE 1 → CRITICAL FACILITIES OPERATIONALLY IMPACTED BY THE FAILED FACILITY	HHW & P Facilities											
	COLUMN (1) CRITICAL FACILITY ASSUMED TO FAIL	Moccasin Switchyard	Moccasin Powerhouse/Penstock	Moccasin Reservoir/Bypass (1)	Moccasin Dam/Reservoir	Priest Dam, Reservoir, Outlet & Tunnel	Mountain Tunnel/South Fork Crossing	Kirkwood Powerhouse/Penstock	Holm Powerhouse/Penstock	Cherry Valve House	Early Intake	Canyon Power Tunnel	O'Shaughnessy Dam
CDD Westside	Potrero Heights Pump Station												
	Stanford Heights Reservoir/Feeder Mains												
	Central Pump Station												
	Merced Manor Reservoir												
	Summit Pump Station												
	Summit Reservoir Feeder Mains												
	Sutro Reservoir/Feeder Mains												
	Lake Merced Pump Station												
	Sunset Reservoir/Feeder Mains												
CDD Eastside	Mclaren Pump Station/Tanks												
	College Hill Reservoir/Feeder Mains												
	Bay Bridge Pump Station (1)												
	Cross Town Pipeline (1)												
	Alemany Pump Station												
	University Mound Reservoir/Feeder Mains												
WS & TD Peninsula	Sunset Supply Line (1)												
	San Pedro Valve Lot												
	Baden Pump Station												
	Capuchino Valve Lot												
	Harry Tracy Water Treatment Plant					●	●					●	●
	San Andreas Reservoir					●	●					●	●
	Crystal Springs/San Andreas Pipeline					●	●					●	●
	Crystal Springs Pipeline No. 2												
	Pilarcitos Dam, Reservoir & Tunnel												
	Crystal Springs Pump Station					●	●					●	●
	Crystal Springs Bypass Pipeline/Tunnel												
	Crystal Springs Dam/Reservoir					●	●					●	●
WS & TD South Bay	Pulgas Tunnel Valve Lot												
	Pulgas Balancing Reservoir/Pump Station												
	Bay Division Pipelines 1 & 2 (Mid-section)												
	Bay Division Pipelines 1 & 2 (End sections)												
	Bay Division Pipelines 3 & 4												
WS & TD Sunol Valley System	Irvington Tunnel					▨	▨					▨	▨
	Alameda Creek Siphons					▨	▨					▨	▨
	Sunol Valley Water Treatment Plant					●	●					●	●
	San Antonio Reservoir/Turner Dam												
	San Antonio Pump Station (1)+D37					●	●					●	●
	Calaveras Dam					●	●						●
HHW&P Facilities	Coast Range Tunnel					▨	▨					▨	▨
	Tesla Portal Chlorination Station											▨	▨
	San Joaquin Pipelines 1, 2 and 3/Oakdale Portal					▨	▨					▨	▨
	Roselle Crossing (1)					▨	▨					▨	▨
	Rock River Lime Plant												
	Foothill Tunnel/Red Mountain Bar Siphon/Oakdale Portal					▨	▨					▨	▨
	Moccasin Switchyard	■											
	Moccasin Powerhouse/Penstock		■										
	Moccasin Reservoir Bypass (1)			■	●								
	Moccasin Dam/Reservoir			●	■								
	Priest Dam, Reservoir, Outlet & Tunnel	▨	▨			■	▨						
	Mountain Tunnel/South Fork Crossing		▨			▨	■						
	Kirkwood Powerhouse/Penstock							■				●	
	Holm Powerhouse/Penstock								■				
	Cherry Valve House								▨	■			
	Early Intake								▨		■		
	Canyon Power Tunnel					●	●	▨		●	●	■	
	O'Shaughnessy Dam					●	●	▨		●	●	▨	■

al in Phase I Study

■ Completely Impacted

◢ Partially Impacted

		Column (2) SERVICE AREA IMPACTED						CDD Westside									CDD Eastside						WS & TD Peninsula												WS & TD South Bay					WS & TD Sunol Valley System						HHW & P Facilities																	
	COLUMN (1) CRITICAL FACILITY ASSUMED TO FAIL LINE 1 → CRITICAL FACILITIES OPERATIONALLY IMPACTED BY THE FAILED FACILITY	City Distribution Division Westside	City Distribution Division Eastside	WS&TD North of Pulgas	WS&TD. South of Pulgas	unol Area Customers	Up Country Customers	Potrero Heights Pump Station	Stanford Heights Reservoir/Feeder Mains	Central Pump Station	Merced Manor Reservoir	Summit Pump Station	Summit Reservoir/Feeder Mains	Sutro Reservoir/Feeder Mains	Lake Merced Pump Station	Sunset Reservoir/Feeder Mains	Mclaren Pump Station/Tanks	College Hill Reservoir/Feeder Mains	Bay Bridge Pump Station (1)	Cross Town Pipeline (1)	Alemany Pump Station	University Mound Reservoir/Feeder Mains	Sunset Supply Line (1)	San Pedro Valve Lot	Baden Pump Station	Capuchino Valve Lot	Harry Tracy Water Treatment Plant	San Andreas Reservoir	Crystal Springs/San Andreas Pipeline	Crystal Springs Pipeline No. 2	Pilarcitos Dam, Reservoir & Tunnel	Crystal Springs Pump Station	Crystal Springs Bypass Pipeline/Tunnel	Crystal Springs Dam/Reservoir	Pulgas Tunnel/Valve Lot	Pulgas Balancing Reservoir/Pump Station	Bay Division Pipeline 1 & 2 (Midsection)	Bay Division Pipelines 1 & 2 (End Sections)	Bay Division Pipelines 3 & 4	Irvington Tunnel	Alameda Creek Siphons	Sunol Valley Water Treatment Plant	San Antonio Reservoir/Turner Dam	San Antonio Pump Station (1)	Calaveras Dam	Coast Range Tunnel	Tesla Portal Chlorination Station	San Joaquin Pipelines 1, 2 and 3/Oakdale Portal	Roselle Crossing (1)	Rock River Lime Plant	Foothill Tunnel/Red Mountain Bar Siphon/Oakdale Portal	Moccasin Switchyard	Moccasin Powerhouse/Penstock	Moccasin Reservoir/Bypass (1)	Moccasin Dam/Reservoir	Priest Dam, Reservoir, Outlet & Tunnel	Mountain Tunnel/South Fork Crossing	Kirkwood Powerhouse/Penstock	Holm Powerhouse/Penstock	Cherry Valve House	Early Intake	Canyon Power Tunnel	O'Shaughnessy Dam
CDD Westside	Potrero Heights Pump Station	◢						█	○	○	○	○	○	○	●	●	○	○	○			●													●			●	●	●	●																						
	Stanford Heights Reservoir/Feeder Mains	◢						○	█	○	○	○	○	○	●	●	○	○	○			●													●			●	●	●	●																						
	Central Pump Station	◢						○	▨	█	○	○	○	○	●	●	○	○	○			●																																									
	Merced Manor Reservoir	◢						○	○	○	█	○	○	○	●	●	○	○	○			●													●			●	●	●	●																						
	Summit Pump Station	◢						○	○	○	○	█	▨	○	●	●	○	○	○			●													●			●	●	●	●																						
	Summit Reservoir Feeder Mains	◢						○	○	○	○	○	█	○	●	●	○	○	○			●													●			●	●	●	●																						
	Sutro Reservoir/Feeder Mains	◢						○	○	○	○	○	○	█	●	●	○	○	○			●													●			●	●	●	●																						
	Lake Merced Pump Station	◢						○	○	○	○	○	○	▨	█	●	○	○	○	○	○	●													●			●	●	●	●																						
	Sunset Reservoir/Feeder Mains	◢	◢					○	○	○	○	○	○	○	○	█	○	○	○	○	○	●				●									●			●	●	●	●																						
CDD Eastside	Mclaren Pump Station/Tanks		◢					○	○	○	○	○	○	○	●	●	█	○	○			●													●			●	●	●	●																						
	College Hill Reservoir/Feeder Mains		◢					○	○	○	○	○	○	○	●	●	○	█	○			●													●			●	●	●	●																						
	Bay Bridge Pump Station (1)		a					○	○	○	○	○	○	○	●	●	○	○	█			●													●			●	●	●	●																						
	Cross Town Pipeline (1)	◢	◢					○	○	○	○	○	○	○	●	●	○	○	○	█	○	●													●			●	●	●	●																						
	Alemany Pump Station	◢	◢					○	○	○	○	○	○	○	●	●	○	○	○	▨	█	●													●			●	●	●	●																						
	University Mound Reservoir/Feeder Mains	◢	◢					○	○	○	○	○	○	○	●	●	○	○	○	○		█													●			●	●	●	●																						
WS & TD Peninsula	Sunset Supply Line (1)	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	█	●						●					●			●	●	●	●																						
	San Pedro Valve Lot	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	▨	█						●					●			●	●	●	●																						
	Baden Pump Station	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●	●	█					●					●			●	●	●	●																						
	Capuchino Valve Lot		◢	◢				○	○	○	○	○	○	○	●	●	○	○	○			●				█				●					●			●	●	●	●																						
	Harry Tracy Water Treatment Plant	◢	◢	◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●	●	●		█	▨	▨	●	▨	▨	●	▨	●	●		●	●	●	●					●	●	●	●		●					●	●					●	●
	San Andreas Reservoir	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●	●	●		▨	█	▨	●	▨	▨	●	▨	●	●		●	●	●	●					●	●	●	●		●					●	●					●	●
	Crystal Springs/San Andreas Pipeline	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●	●	●		▨	▨	█	●	▨	▨	●	▨	●	●		●	●	●	●					●	●	●	●		●					●	●					●	●
	Crystal Springs Pipeline No. 2		◢	◢				○	○	○	○	○	○	○	●	●	○	○	○	○		●	●				●	●	●	█		●		●				●	●	●	●																						
	Pilarcitos Dam, Reservoir & Tunnel	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○			●									█																																
	Crystal Springs Pump Station	◢		◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●		●		▨	▨	▨	●		█	●	▨	●	●		●	●	●	●					●	●	●	●		●					●	●					●	●
	Crystal Springs Bypass Pipeline/Tunnel	◢	◢	◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●			●	●	●	●	●		●	█	●	●	●		●	●	●	●																						
	Crystal Springs Dam/Reservoir	◢	◢	◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●	●	●		▨	▨	▨	●		▨	●	█	●	●		●	●	●	●					●	●	●	●		●					●	●					●	●
WS & TD South Bay	Pulgas Tunnel Valve Lot	◢	◢	◢				○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	●	●		●	●	●	●	●	●	●	●	●	█	▨		●	●	●	●																						
	Pulgas Balancing Reservoir/Pump Station			◢	◢			○	○	○	○	○	○	○	●	●	○	○	○	○	○	●				●	●	●	●			●		●	●	█		●	●	●	●																						
	Bay Division Pipelines 1 & 2 (Mid-section)	◢	◢	◢																															●	●	█	●	●	●	●																						
	Bay Division Pipelines 1 & 2 (End sections)	◢	◢	◢	◢			○	○	○	○	○	○	○	●	●	○	○	○	○	○	●				●	●	●	●	●		●		●	●	●	▨	█	●	●	●																						
	Bay Division Pipelines 3 & 4	◢	◢	◢	◢			○	○	○	○	○	○	○	●	●	○	○	○	○		●				●	●	●	●	●		●		●	●	●	●	●	█	●	●																						
WS & TD Sunol Valley System	Irvington Tunnel	◢	◢	◢	◢			○	○	○	○	○	○	○	●	●	○	○	○	○		●	●			●	●	●	●	●	●	●	●	●	●	●		●	●	█	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨					▨	▨					▨	▨
	Alameda Creek Siphons	◢	◢	◢	◢	◢		○	○	○	○	○	○	○	●	●	○	○	○	○		●	●			●	●	●	●	●	●	●	●	●	●	●		●	●	▨	█	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨					▨	▨					▨	▨
	Sunol Valley Water Treatment Plant			◢	◢	◢		○	○	○	○	○	○	○	●	●	○	○	○			●	●												●	●		●	●	●	●	█			▨	●	●	●	●		●					●	●					●	●
	San Antonio Reservoir/Turner Dam							○	○	○	○	○	○	○	●	●	○	○	○			●																					█																				
	San Antonio Pump Station (1)+D37	◢	◢	◢	◢			○	○	○	○	○	○	○	●	●	○	○	○			●													●	●		●	●	●	●			█		●	●	●	●		●					●	●					●	●
	Calaveras Dam	◢	◢	◢	◢			○	○	○	○	○	○	○	●	●	○	○	○			●													●	●		●	●	●	●				█	●	●	●	●		●					●	●						●
HHW & P Facilities	Coast Range Tunnel			◢	◢			○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●	█	▨	▨		▨	▨					▨	▨					▨	▨
	Tesla Portal Chlorination Station			◢	◢			○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●			█															▨	▨
	San Joaquin Pipelines 1, 2 and 3/Oakdale Portal			◢	◢			○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●	▨	▨	█	▨	▨	▨					▨	▨					▨	▨
	Roselle Crossing (1)			◢	◢			○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●	▨	▨	▨	█	▨	▨					▨	▨					▨	▨
	Rock River Lime Plant							○	○	○	○	○	○	○	●	●	○	○	○			●																												█													
	Foothill Tunnel/Red Mountain Bar Siphon/Oakdale Portal	◢	◢	◢	◢	◢	■	○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●	▨	▨	▨	▨	▨	█					▨	▨					▨	▨
	Moccasin Switchyard							○	○	○	○	○	○	○	●	●	○	○	○			●																														█											
	Moccasin Powerhouse/Penstock	◢	◢	◢	◢	◢	■	○	○	○	○	○	○	○	●	●	○	○	○			●																															█										
	Moccasin Reservoir Bypass (1)	◢	◢	◢	◢	◢	■																																															█	●								
	Moccasin Dam/Reservoir	◢	◢	◢	◢	◢	■																																															●	█								
	Priest Dam, Reservoir, Outlet & Tunnel	◢	◢	◢	◢	◢	■	○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●	▨	▨	▨	▨	▨	▨	▨	▨			█	▨						
	Mountain Tunnel/South Fork Crossing	◢	◢	◢	◢	◢	■	○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●	▨	▨	▨	▨	▨	▨		▨			▨	█						
	Kirkwood Powerhouse/Penstock	◢	◢	◢	◢	◢	◢	○	○	○	○	○	○	○	●	●	○	○	○			●	●	●			●	●	●	●		●		●	●	●		●	●	●	●	●	●	●	●													█				●	
	Holm Powerhouse/Penstock						■																																																				█				
	Cherry Valve House																																																										▨	█			
	Early Intake						◢																																																				▨		█		
	Canyon Power Tunnel	◢	◢	◢	◢	◢	◢	○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●			●		●	●	●		●	●	●	●	●		●	●	●	●	●	●		●					●	●	▨		●	●	█	
	O'Shaughnessy Dam	◢	◢	◢	◢		■	○	○	○	○	○	○	○	●	●	○	○	○			●	●				●	●	●			●		●	●	●		●	●	●	●	●		●	●	●	●	●	●		●					●	●	▨		●	●	▨	█

a Treasure Island Only

○ City Facilities that must remain operational

● Regional System Facilities that must remain operational

█ Facility Assumed to Fail

▨ Facility Rendered Inoperable as the Result of the Failed Facility

(1) Facilities Not Considered Critical in Phase I Study

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT: Technical Memorandum No. 4
Phase III Work Plan and Other Recommendations

PREPARED BY: The Water Reliability Partnership

DATE: July 30, 1999

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT:	Technical Memorandum No. 4 **Phase III Work Plan and Other Recommendations**
PREPARED BY:	The Water Reliability Partnership
DATE:	July 21, 1999

1.0 INTRODUCTION

The San Francisco Public Utilities Commission (SFPUC) system currently delivers water to 2.4 million people through 29 wholesale customers, and directly to retail customers within the City of San Francisco. About 60 to 70 percent of the SFPUC supply is delivered through a storage and conveyance system transporting water from as far away as the Sierra Nevada to the Bay Area. Most of the SFPUC water and power system facilities are very potentially vulnerable, being 60 to 80 years old and conveying water across numerous earthquake faults.

As a result, the SFPUC in collaboration with the San Francisco Bay Area Water Users Association (BAWUA), is developing a program to secure the long term reliability of its water and power systems during and following catastrophic events. The Facilities Reliability Program has the following objectives:

- Protect water and power facilities from damage or failure due to seismic events or other natural catastrophes;
- Minimize or eliminate disruptions to water deliveries and water and power revenues resulting from such events, and
- Avoid potential loss or damage to life, property, business, or the environment resulting from failure of SFPUC/BAWUA facilities in such events.

The Phase I Facilities Assessment identified the criticality of each facility and assessed its potential vulnerability to damage or failure from a variety of physical events. This Technical Memorandum (TM) No. 4 summarizes the findings and recommendations from Phase II of the SFPUC Facilities Reliability Program and presents the scope of work and work plan for Phase III. The Phase II effort:

- identified key hazards to be carried forward into the Phase III analysis,
- presented key decisions and developed a framework for assessing reliability, and
- identified early implementation projects, based on problem areas and weak links in the system.

Phase III of the program provides the more detailed analysis of the reliability of the SFPUC system resulting in recommendations of prioritized improvements.

2.0 SUMMARY OF PHASE II

This section presents an overview of the Phase II approach, its findings, and recommendations for activities that should be implemented now.

2.1 Phase II Approach

Phase II consisted of the following key steps.

- Prepare Project Management Plan
- Develop Hazard Mapping
- Define Baseline Reliability Assumptions
- Characterize Baseline Reliability Response
- Identify Recommendations for Early Implementation Activities
- Develop Phase III Work Plan

Important information on hazards that was not available to the SFPUC during the Phase I effort, such as earthquakes of significance, their magnitudes, and potential impacts to facilities, was developed during Phase II. Assessing the potential impacts associated with other hazards, such as landslides, resulted in the recommendation for Phase II to focus on regional catastrophic hazards since the regional hazards encompass impacts of isolated facilities hazards.

A characterization of the baseline reliability of the SFPUC system and of the City Distribution Division (CDD) system was conducted by first identifying assumptions, or examples of key decisions that will have to be made during Phase III with more thorough data. These assumptions were then applied in a time sequence analysis of how the system may respond to the selected earthquake hazard events. The analysis provided a general overview of the reliability of the existing system in terms of its ability over time to meet system demands following an event. From this analysis, data needs were identified and a general approach for the Phase III work was established.

Although this Phase II baseline reliability characterization was based on preliminary assumptions (i.e., not site specific data), weak links and problem areas became apparent. Based on the weak links, readily apparent vulnerability reduction activities were identified and are called early implementation activities.

2.2 Findings from the Hazards Assessment and Baseline Reliability Characterization

Determination of Catastrophic Hazards for Reliability Analysis. Various hazards that could potentially impact the SFPUC system were identified in Phase I and reviewed in Phase II. TM No. 1, Hazard Events and Mapping, provided additional information on the hazards, particularly seismic hazards that could significantly impact the ability of the system to deliver water following an event. The major faults that cross or are located proximate to SFPUC facilities include the San Andreas fault, Hayward fault, Calaveras fault, Great Valley fault zone, and the Greenville fault. These faults have potential for large magnitude events capable of causing strong ground shaking and serious damage. The first four events listed here pose the greatest range of concern to the system and were selected for Phase III analysis; these hazards represent catastrophic regional impacts to the system. Impacts associated with the Greenville fault are addressed within the Calaveras and Great Valley events.

Impacts associated with other earthquake events and other hazards may have more isolated effects on system facilities and supplies versus regional effects, and or the impacts are addressed within one of these earthquake scenarios. Earthquake events can result in ground shaking, fault rupture, liquefaction, landslides, power failure, and fire; these associated impacts are taken into account when assessing the reliability of the SFPUC system under these four hazard scenarios.

Determination of Magnitudes and Peak Ground Accelerations. The magnitude of the four seismic events are provided in Table 1 below. These magnitudes represent the maximum probable event on each fault and are described in more detail in TM No.1. The peak ground accelerations (PGAs) associated with each of these events have been mapped, with the SFPUC facilities overlaid thereon. The PGAs are particularly high for the San Andreas event and are anticipated to significantly impact SFPUC facilities, especially on the Peninsula and in the City of San Francisco.

Table 1

Earthquake Hazard Events

Mw 7.1*	Hayward Fault
Mw 6.8	Calaveras Fault
Mw 7.9	San Andreas Fault
Mw 6.7	Great Valley Fault Zone

* Mw = moment magnitude

Additions to Critical Facilities List. Critical SFPUC water and power facilities of the system were initially identified during Phase I and augmented in Phase II. As described in TM No 3, the operational roles of these facilities were reviewed to determine the linkage of facilities currently providing a flow of water through the system. Based on the identification of the system's response capability as determined in the characterization of baseline reliability, several critical facilities were added to the Phase I list. The resulting critical facilities are provided in TM No. 2.

Identification of Data Gaps. One of the results of the characterization of baseline reliability of the SFPUC system was the determination of existing data available for the more thorough Phase III reliability analysis. Key data and decisions were identified as assumptions and used as placeholders for the baseline characterization. A baseline reliability analysis should be conducted in Phase III utilizing more rigorous data and decisions as described in Section 3.0 of this TM. The key data and decisions described in technical memoranda 2 and 3 require more thorough analyses prior to use in a rigorous baseline reliability analysis.

Because of the importance of the critical facilities to the system, it is recommended that structural and geotechnical assessments be conducted on the critical facilities (before, or early in Phase III) and the results used in Phase III. A probability of failure analysis is also needed for each critical facility; this would be based on the assessments, along with other data such as PGAs.

The anticipated demand for water used in the baseline reliability analysis, preliminarily identified in TM No. 2, need to be revisited with more thorough data on each customer system. Targeted service objectives are also required to compare against quantified baseline reliability results in order to determine the desirable reliability of the system.

Permanent restoration times were identified in Phase I for each critical facility. These repair times should be revisited with the new hazards data and augmented with temporary repair times for each facility.

2.3 Early Implementation Activities - Scopes of Work

The baseline reliability characterization conducted in Phase II provided an initial insight to the more apparent weak links and problem areas of the system which have obvious projects or activities to solve their inadequacies. These obvious projects may be initiated without further analysis in Phase III and are described below as Early Implementation Activities. Additional detail on these Early Implementation Activities is provided in Appendix A as a scope of work for each project. The scopes of work identify the key steps for each activity, from environmental compliance and permitting to construction. The SFPUC should review the existing CIP in light of these recommended activities, and use this information to prioritize existing projects or augment the CIP with new activities.

One of the Early Implementation Activities identified in Appendix A is to conduct structural and geotechnical evaluations of each critical facility. This information is vital to the Phase III analysis to ensure that the conclusions represent a thorough and rigorous process. To support the recommended facilities evaluations, Facilities Data Sheets were prepared for each critical facility. These data sheets provide specific information known about each facility such as age of construction, the PGA associated with the most severe earthquake, etc., as well as information that is not known which should be determined. These Facilities Data Sheets are provided in Appendix B. Customer connections to SFPUC facilities are also included as a data sheet.

SFPUC Regional System

New Bay Division Pipeline Augmenting 1 and 2. Bay Division Pipelines (BDPL's) Nos. 1 and 2 are the main source of supply for East Bay water providers including the City of Hayward and Alameda County Water District. These pipelines also provide water to the San Francisco Peninsula. Therefore, reliability of BDPL's Nos. 1 and 2 is critical. However, the pipelines appear to have significant reliability deficiencies. Due to their deteriorating condition, they are not likely to withstand seismic events occurring on nearby faults including the Hayward Fault, the Calaveras Fault, and the San Andreas Fault. Therefore, it is necessary to replace, or augment with the same capacity, BDPL's Nos. 1 and 2 with a new pipeline. This project involves analyses of alternative alignments and configurations, design, and implementation of improvements to increase the reliability of water supply to customers in the East Bay and the San Francisco Peninsula.

Bay Division Pipeline No. 3 and 4 Cross Connections. Bay Division Pipelines (BDPL's) Nos. 3 and 4 are critical conduits for conveying water to the South Bay and the San Francisco Peninsula. These pipelines cross liquefaction zones and faults that are potential points of pipe failures during a seismic event. Reliability of BDPL's Nos. 3 and 4 can be enhanced by constructing cross connections with appropriate valves that would allow water to be diverted from one pipeline to the other in the event of a pipe failure. Cross connection points would be located near the edges of fault and liquefaction zones (upstream and downstream of potential failure points). Thereby, capability to bypass pipe segments with the greatest potential for failure would be provided. As a part of this activity, the structural integrity of the existing cross connections could be reviewed and rehabilitation recommendations made, if necessary.

Palo Alto Pipeline Connection. The current connection point to the Bay Division Pipelines Nos. 1 and 2 limits the flexibility to provide service to customers in Redwood City, Menlo Park, Atherton, and portions of unincorporated San Mateo County following an event. A catastrophic failure of the two pipelines would severely limit water supply to these communities. The existing connection location also limits the capability to perform repairs to BDPL's Nos. 1 and 2 in particular locations. For this project, the existing Palo Alto pipeline would be extended to connect with BDPL's Nos. 3 and 4.

Harry Tracy WTP Structural Analyses. The Harry Tracy Water Treatment Plant (HTWTP) is a critical facility for delivering safe potable water to SFPUC customers. If the Hetch Hetchy and Calaveras supplies are disrupted and the Sunol WTP is not able to operate, the HTWTP will be the only remaining treatment facility to provide potable water. Therefore, it is critical that the HTWTP be able to withstand a seismic event and satisfy demand if water is not available from other sources. This project also involves development of facilities to allow raw water from San Andreas Reservoir to bypass the HTWTP in the event that it is heavily damaged.

Pulgas Tunnel Pressure Improvements. The Pulgas Tunnel and Bypass Tunnel near Upper Crystal Springs Reservoir currently operate in an open channel flow condition or at very low pressurization. The overflow weir into Upper Crystal Springs Reservoir maintains this condition at most times. If the HTWTP were to backfeed the system, pressure is limited. Most problems would be solved if the Pulgas Tunnel and Bypass Tunnel could operate at a pressure of about 30 feet of water column.

The Pulgas Tunnel and Bypass Tunnel were constructed in 1924 and 1969, respectively. Neither of these tunnels appears to have been designed to operate under pressurized conditions. This project involves reviewing the pressure carrying capacity of the tunnels and design of improvements to increase the pressure capacity of the tunnels if necessary. Inspection of the tunnel may also be needed.

Harry Tracy WTP Backfeed Capability Analyses. The Hetch Hetchy system and Sunol WTP are currently the only sources of potable water for the customers it serves in the South Bay and East Bay. If these supplies are disrupted, most of the customers will be without potable water.

Therefore, it may be necessary to provide a backup source by adding capability to feed potable water from the HTWTP backwards through the Bay Division Pipelines to customers in the South Bay and East Bay. This project involves studying the feasibility of backfeeding water from the HTWTP as far back as Hayward. It augments other related individual backfeed facility analyses by providing a thorough regional system analysis of the backfeeding capability.

Capuchino Valve Lot Capacity Improvements. As described above, it is desirable to provide the capability to backfeed potable water from the HTWTP through the Bay Division Pipelines to customers in the East Bay and South Bay. The Capuchino Valve Lot is a critical element to permit backfeeding from the HTWTP and pressurization of the Pulgas Tunnel. This project involves analyzing the Capuchino Valve lot to determine what improvements are needed to provide backfeed capability and implementation of the recommended improvements. Improvements to increase the seismic reliability of the valve lot are also included in this project.

Irvington Tunnel Reliability Improvements. The Irvington Tunnel is the only conduit available to convey water from Hetch Hetchy system and Sunol WTP to the Bay Division Pipelines. Therefore, the tunnel and its portals are critical for system reliability. This project involves increasing the reliability of the tunnel, and more specifically the west portal, to survive PGA's of 0.6 to 0.7 g, providing bypass capability, or providing means to repair the tunnel/portal within 30 days of a seismic event.

Crystal Springs Pump Station and Crystal Springs-San Andreas Pipeline Capacity Improvements. If the Hetch Hetchy and Sunol WTP supplies are disrupted, water from the Crystal Springs and San Andreas Reservoirs and treatment at the HTWTP will become more critical. Therefore, it will be necessary to improve the raw water feed capacity and reliability from the San Andreas Reservoir and the Crystal Springs Reservoir to the Harry Tracy WTP. Since feed water to the HTWTP cannot be drawn directly from Crystal Springs Reservoir, it is necessary to first transfer water from Crystal Springs to San Andreas via the Crystal Springs Pump Station and the Crystal Springs-San Andreas Pipeline. This project involves increasing the capacity of the Crystal Springs Pump Station and the Crystal Springs-San Andreas Pipeline, and the seismic reliability of these facilities and the pipeline to the HTWTP.

Santa Clara Valley Water District Intertie. This project will provide facilities for an intertie between the Santa Clara Valley Water District and SFPUC water supply systems. The intertie will provide up to 40 mgd in either direction. It is intended to provide water for health and safety needs in the event of major facility failures, to provide a sole source of supply during planned pipeline shutdowns of certain segments of the system for inspections and repairs, and to provide the capability for temporary wheeling of water to overcome shortages.

All Critical Facilities – Structural, Geotechnical, and Other Seismic Assessments. This project involves the assessment of reliability deficiencies in all critical facilities. Geotechnical, structural, and general reliability investigations and assessments will be conducted for each facility and the results utilized in Phase III of the Facilities Reliability Program. Facility vulnerabilities and obvious fixes will be identified.

Pipeline Repair Prioritization Plan. This project involves development of a response plan for major seismic events. The response plan will include a detailed priority list of critical facilities that may be damaged during a seismic event. The priority list will identify the order in which facilities should be repaired to restore service to the maximum number of customers in the shortest time frame possible.

Sunset and University Mound Reservoirs - Reservoir Roof Reinforcement. The roof of the North Basin of Sunset Reservoir has the highest priority of all the City reservoirs for seismic retrofitting. The reservoir roof was constructed in 1938 and besides being seismically deficient, the concrete roof has spalled in many locations. Similar seismic improvements will be required at the University Mound Reservoir. The University Mound Reservoir is particularly vulnerable because it does not have an adequate back-up facility. This project will involve investigations, development of rehabilitation alternatives, and implementation of reliability improvements.

Crystal Springs Pipeline No. 1 Construction. Replacement of portions of the old Crystal Springs Pipeline No. 1, which has extensive leaks, is critical to assure reliable water supply to the customers both on the Peninsula and in the eastern portion of San Francisco. This project, which is already underway, will replace approximately 13,300 feet of existing pipe with new steel pipe.

Baden Pump Station Improvements. Baden Pump Station conveys water from Crystal Springs Pipeline No. 2 and the Sunset Supply Pipeline to San Andreas Pipeline No. 2 and ultimately to customers in Daly City, to California Water Service Company, and to the higher pressure zones in the CDD service area. This pump station is an important facility to convey Hetchy water to the CDD high zones if the Peninsula supplies are disrupted. This project involves evaluating, designing, and implementing improvements to increase the reliability of the pump station.

City Distribution Division System

North Area of City - Additional Storage. Additional storage capacity is needed to assure an adequate water supply to customers in the northeast portions of the City in the event that the supplies are disrupted. This project involves studying, designing, and constructing additional storage capacity by rebuilding Francisco Reservoir at a higher elevation or adding storage in or near the Presidio.

College Hill and Summit Reservoirs - Reservoir Roof Reinforcement. College Hill and Summit Reservoirs are critical elements for maintaining potable water in the distribution system immediately after a seismic event. This project involves completing site surveys, and internal and external inspection of the reservoirs. Flexible connections will be evaluated to replace rigid connections between such items as piping and tanks. Reservoir roofs will be inspected and evaluated for seismic design. Roof seals and expansion joints will be investigated for deterioration and leaks.

Lake Merced Emergency Supply Improvements. Lake Merced may be connected to the distribution system (via a standby treatment facility) to greatly increase the emergency supply of potable water within San Francisco. If Lake Merced water is available, the reliability of the system will be greatly increased. Improvements to permit use of Lake Merced water during an emergency include lowering the intake structure at the lake, constructing standby treatment facilities to process up to 20 mgd, and improving pipelines and pumping facilities to convey the water into the system. Treatment facilities may include pressure filters, membrane filtration, and/or disinfection. Creative treatment options, such as a portable treatment unit from a manufacturer, should be investigated. Although Lake Merced water could possibly be utilized to meet both potable and fire fighting demands, the baseline reliability analysis (see Technical Memorandum No. 3) indicated that it is of more value as a potable supply over an extended period of time following a seismic event.

Groundwater Master Plan Implementation. The San Francisco Groundwater Master Plan (Draft July 1996) recommended numerous programs and projects to protect and use groundwater, including development of groundwater protection and saltwater intrusion prevention programs, installation of new production wells, and formation of a groundwater unit within the SFPUC. Implementation of this plan will result in an increase of several million gallons a day of groundwater supply to the City. This supply should also have the ability to be integrated into the CDD distribution system during an emergency.

Backbone Pipeline System Development. A backbone distribution system is needed to assure that an adequate supply can be conveyed to customers in the most vulnerable parts of the City (north waterfront and downtown areas of University Mound pressure zone) immediately following a seismic event, as well as when the regional supply becomes available to the CDD. This project involves studying, designing, and constructing a backbone pipeline system to convey water from the regional system supply facilities to new storage facilities in the northern area of the City to customers across the north and northeast portions of the City. The pipeline could be implemented by reconstructing strategic sections of existing pipelines to increase their capacities. Alternatively, entirely new pipeline segments could be constructed to make up the backbone system.

Pipeline Repair Prioritization Plan. This project involves development of a response plan for major seismic events. The response plan will include a detailed priority list of critical facilities that may be damaged during a seismic event. The priority list will identify the order in which facilities should be repaired to restore service to the maximum number of customers in the shortest time frame possible. For example, for the western part of the City, the larger pipelines between Sunset, Sutro, and Summit reservoirs should be a high priority for repair.

All Critical Facilities – Structural, Geotechnical, and Other Assessments. This project involves identification and assessment of reliability deficiencies in facilities included in Phase III of the reliability program that are not otherwise identified as early implementation projects. Geotechnical, structural, and general reliability investigations and assessments will be conducted for each facility. Recommended improvements will be presented for implementation under separate projects.

BAWUA Agencies

Customer Distribution System Evaluations or Updates with Phase II Hazards. Information is needed for the Phase III analysis on the water demand response for the individual BAWUA customers. In particular, data on the customer's anticipated demands between Day 2 and Day 30 are needed for Phase III. These data could either be provided by the customers or assumptions made which can be reviewed and commented on by the customers.

For their own information, if not already done, the customers should also conduct an assessment of the ability of their facilities to response to an event, such as storage availability, extent of pipe brakes, fragility of pump stations, etc. Phase III will result in improvements associated with particular levels of overall SFPUC system reliability. This information should then be fed back to the BAWUA members to aid them in planning for anticipated outages and determining what improvements are needed to their systems to ensure distribution capabilities once the regional supply is restored.

It is recommended that a workshop be held with the customers at the start of this early implementation activity to discuss Phase III data needs and the iterative steps between the project and BAWUA members. A suggested scope of work for the BAWUA members is provided in Appendix C.

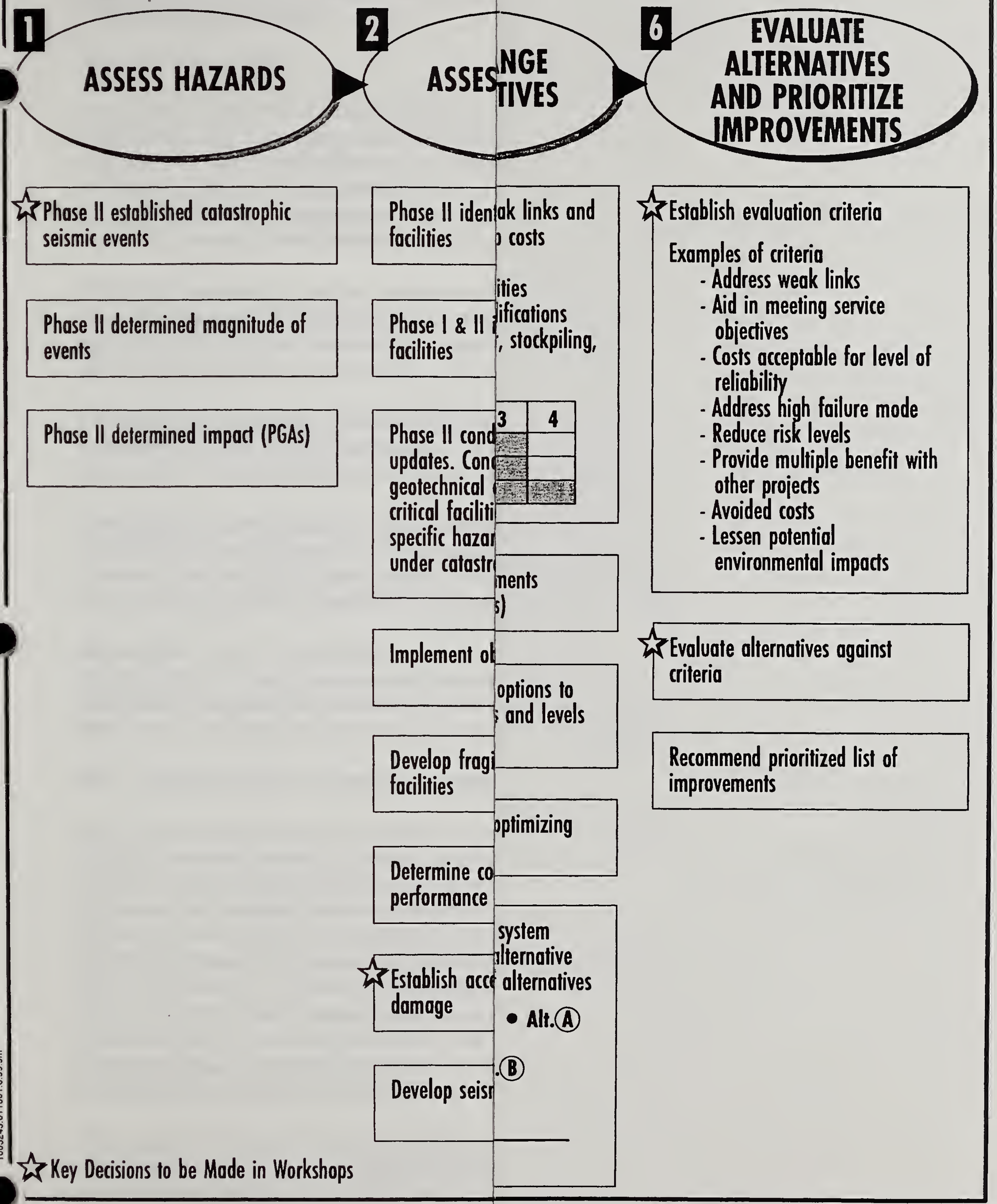
3.0 SCOPE OF WORK FOR PHASE III RELIABILITY ANALYSIS

A recommended scope of work for the more thorough, quantified Phase III reliability analysis is summarized in Figure 1 and provided here. This more rigorous analysis is based on the framework identified during the development of the Phase II baseline reliability characterization. However, more thorough and current, site specific data as well as key assumptions and decisions are needed during Phase III. Since it is unknown which of the early implementation activities from Section 2.3, above, will be underway at the start of Phase III, Step 4, below, specifies the need to identify capacity, reliability, and other improvements assumed to be in place for the reliability analysis.

Step 1 - Assess Hazards

Phase III will rely on data and recommendations related to hazards (e.g., seismic events, magnitude, and peak ground accelerations) developed in Phase II. Phase II established four seismic events which catastrophically impact the SFPUC regional system and act as an umbrella for impacts associated with isolated events. Additional hazards will be identified during Step 2 which are related to specific facilities with impacts not already accommodated under the regional catastrophic seismic events.

Deliverable: More detailed maps of PGAs associated with each facility for the selected four seismic events. Technical Memoranda No. 1 and 2 prepared during Phase II provide a text description of the hazards recommended to continue into Phase III.



1 ASSESS HAZARDS

2 ASSES NGE TIVES

6 EVALUATE ALTERNATIVES AND PRIORITIZE IMPROVEMENTS

☆ Phase II established catastrophic seismic events

Phase II determined magnitude of events

Phase II determined impact (PGAs)

Phase II iden ak links and
facilities) costs

ities
Phase I & II ifications
facilities , stockpiling,

Phase II cond
updates. Con
geotechnical
critical faciliti
specific hazar
under catastr ments
s)

Implement ob

options to
s and levels

Develop fragi
facilities

optimizing

Determine co
performance

system
lternative
☆ Establish acc alternatives
damage
• Alt.Ⓐ

.Ⓑ
Develop seisr

☆ Establish evaluation criteria

Examples of criteria
- Address weak links
- Aid in meeting service objectives
- Costs acceptable for level of reliability
- Address high failure mode
- Reduce risk levels
- Provide multiple benefit with other projects
- Avoided costs
- Lessen potential environmental impacts

☆ Evaluate alternatives against criteria

Recommend prioritized list of improvements

☆ Key Decisions to be Made in Workshops

SFPUC FACILITIES RELIABILITY PROGRAM

PHASE III RELIABILITY ANALYSIS SCOPE OF WORK

Figure 1

1 ASSESS HAZARDS

☆Phase II established catastrophic seismic events

Phase II determined magnitude of events

Phase II determined impact (PGAs)

2 ASSESS FACILITIES

Phase II identified linkages of facilities

Phase I & II identified critical facilities

Phase II conducted facilities updates. Conduct structural and geotechnical evaluations of all critical facilities. Also Identify specific hazards not addressed under catastrophic events.

Implement obvious fixes

Develop fragility curves for critical facilities

Determine consequences of facility performance

☆Establish acceptable levels of damage

Develop seismic design criteria

3 DETERMINE OTHER RESPONSE CAPABILITIES

Establish customer average day demands

☆Determine customer demand response following event

Phase II identified available water supply sources

☆Identify temporary repair times

☆Establish mutual aid assumptions

Determine power supply availability

Determine capability of communications

4 QUANTIFY SYSTEM VULNERABILITY AND CONSEQUENCES OF FAILURE

☆Identify capacity and reliability improvements assumed to be in place

☆Establish targeted service objectives to use for levels of reliability

Assess (e.g. model) system for baseline conditions

Identify weak links and problem areas

Determine consequences of system vulnerabilities
- Ability to meet demands
- Ability to restore facilities
- Economic impact
- Life safety
- Regulatory compliance (potable/nonpotable)

5 DEVELOP RANGE OF ALTERNATIVES

☆Identify options for weak links and problem areas; develop costs
1. New facilities
2. Fix existing facilities
3. Operational modifications
4. Response (repair, stockpiling, mutual aid)

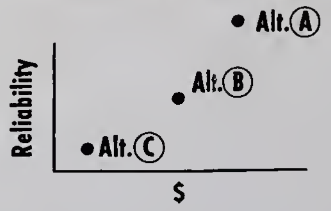
WEAK LINKS	1	2	3	4
X	▨		▨	
Y	▨	▨	▨	
Z			▨	▨

Establish core improvements (part of all alternatives)

Evaluate and package options to reflect a range of costs and levels of reliability

Conduct iterations for optimizing options

Quantify (e.g., model) system reliability under each alternative and determine costs of alternatives



6 EVALUATE ALTERNATIVES AND PRIORITIZE IMPROVEMENTS

☆Establish evaluation criteria

Examples of criteria
- Address weak links
- Aid in meeting service objectives
- Costs acceptable for level of reliability
- Address high failure mode
- Reduce risk levels
- Provide multiple benefit with other projects
- Avoided costs
- Lessen potential environmental impacts

☆Evaluate alternatives against criteria

Recommend prioritized list of improvements

☆Key Decisions to be Made in Workshops

SFPUC FACILITIES RELIABILITY PROGRAM

PHASE III RELIABILITY ANALYSIS
SCOPE OF WORK

Figure 1

Step 2 - Assess Facilities

Assuming that the structural and geotechnical assessments of all critical facilities was or is being conducted as an Early Implementation Activity, obtain the results. This information is very critical to the validity of the Phase III reliability analysis. The results of these assessments will indicate site specific hazards associated with a particular facility that are not already encompassed within a catastrophic seismic hazard. For example, isolated landslide hazards not necessarily associated with earthquakes will be distinguished.

From these assessments, obvious solutions will have emerged; activities which are easy or critical to implement immediately will be recommended for early implementation. The remainder of the obvious solutions (or problems) will be carried forward to subsequent steps of alternatives development and evaluation.

Estimates of the probability of failure will be developed utilizing the critical facilities assessments and the seismic hazards data. The consequences of facility performance during an event will be described utilizing the Phase II information on regional facilities linkages.

A workshop is recommended for staff to establish acceptable levels of damage for each facility. For example, it may be acceptable for a facility to be partially functional after an event to be able to convey some amount of water. Seismic design criteria will also be developed as a part of this step to provide appropriate standards for typical facilities.

Deliverables: Two Technical Memoranda and one workshop. The first Technical Memorandum will summarize the weak links, isolated hazards, and obvious fixes resulting from the seismic assessments, along with the results of this task. The second Technical Memorandum will be prepared on recommended seismic design criteria.

Step 3 - Determine Other Response Capabilities

Other types of response capabilities will be determined for the regional system response and individual customer system responses. An assumption of water demands, e.g., average day demands, maximum day demands, etc., will be made for the time of an event which will affect the demand response after the event. Determine the system demand response/recovery over time following an event. For the regional system, the time frame of Day 2 to Day 30 is the most critical time frame; for the customer distribution systems, a demand response for the first 24 hours is also critical. If information regarding customer demand responses is not available, assumptions will be made based on analyses conducted for other distribution systems. This demand response is not to be confused with service objectives which must be determined in subsequent steps. Appendix C provides an example scope of work for a typical customer distribution system analysis of demand response.

Water supply sources available to the SFPUC regional system, and the assumption on available capacity at the time of the event will be identified. Phase II established an assumption of 65 percent of the capacity of the SFPUC reservoirs. In Phase III, this assumption will be revisited.

Temporary repair times will be established by staff in a workshop which may include persons knowledgeable in construction contracting and earthquake repairs. Temporary repair time assumptions are needed for each critical facility, grouping remaining pipelines into small, medium, and large diameter categories. The determination of time required for partial or full restoration will be made, as appropriate. Crews needed per each repair will be determined and realistic assumptions made regarding estimates of available numbers of crews. Permanent repair times developed during Phase I will be revisited.

Mutual aid assumptions will also be established in a workshop. A determination will be made of materials and equipment, repair crews, and fire fighting capabilities available from other agencies not impacted themselves by the event.

Assumptions will also be established for power supply availability based on discussions with PG&E. The capability of existing communications systems (radio, SCADA, etc.) will be identified in terms of withstanding stresses on regional and SFPUC communication systems following events.

Deliverables: Three workshops and one Technical Memorandum. The Technical Memorandum will summarize the decisions made at the workshops as well as the other response capability assumptions and decisions made. Background materials will be prepared and provided prior to each workshop.

Step 4 - Quantify System Vulnerability and Consequences of Failure

A workshop will be used to identify capacity, reliability, and other improvements assumed to be in place at particular points in time in the future and are therefore considered, for the reliability analyses of future scenarios, a part of the system. These projects will not be included in the development and evaluation of alternatives. Various time frames for the reliability analysis will also be established.

Targeted service objectives will be established in a workshop as initial levels of system reliability to be used in the development and evaluation of alternatives. Targeted service objectives may be based on different types or levels of demands that can uniformly be met through the system following an event, or they can be based on acceptable levels of outages. Later, in Step 5, the optimization task will include the refinement of targeted service objectives.

Utilizing data and assumptions gathered in previous steps, assess the SFPUC system under selected hazard events to establish baseline conditions. This initial assessment provides a baseline upon which to evaluate alternatives in subsequent steps. Weak links and problem areas, such as areas anticipated to have extensive pipe breaks, will be identified through this process, as well as their relative contribution to system performance.

The consequences of system vulnerabilities will also be determined. Consequences may include the system's ability to meet demands, the ability to restore facilities, economic impacts, life safety concerns, regulatory compliance (e.g., potable versus nonpotable supplies, restoring to accommodate a potable supply), and collateral damage issues.

Deliverables: Two workshops and one Technical Memorandum. The Technical Memorandum will summarize the decisions made at the workshops, the results of the baseline reliability assessment, and the consequences of the resulting system vulnerabilities.

Step 5 - Develop Range of Alternatives

Options will be developed to address the weak links and problem areas. These options may consist of constructing new facilities, fixing existing facilities, modifying system operations to work around the problem, and simply responding after the event with repairs and reliance on mutual aid. Costs will be developed for these options. Core improvements will be established which are a part of all alternatives. Core improvements either provide the only logical or reasonable option, or they are simple fixes.

Options will be evaluated against preliminary evaluation criteria and modified until they result in practical, optimized options that can be carried forward. These options will then be packaged to reflect alternative ranges of levels of reliability and ranges of costs. System reliability for selected hazard events under each alternative will be quantified and the costs of the alternatives will be determined. This is a key step in the reliability analysis process.

Deliverables: One workshop and one Technical Memorandum. The Technical Memorandum will present the analysis of options from the workshop along with the results of other subtasks including the development of alternatives.

Step 6 - Evaluate Alternatives and Prioritize Improvements

Evaluation criteria are not only established to develop options, they are also needed to evaluate the alternatives. Evaluation criteria identified in a workshop may include the following: address weak links, meet targeted service objectives, have acceptable costs, reduce risks, provide multiple benefit with other project needs, number of people benefited, number of days of reduced service to customer turnouts, geographic balance of improvements, uniformity of service among all customers, etc. The alternatives will be evaluated against the criteria in a workshop format. The consultant will facilitate this critical workshop and provide support for the participants in making decisions as to the level of reliability desired weighing the costs of investments, risks, and other criteria.

From the evaluation process, a recommended prioritized list of improvements and recommended staging will be developed, and resultant estimated service reliability documented. Interim activities which are needed before the long range projects are in place will also be recommended.

Deliverables: Two workshops and one Technical Memorandum. The Technical Memorandum will present the evaluation criteria and the resulting discussion evaluating levels of reliability with costs and risks. The resulting recommended prioritized list of improvements will also be described.

4.0 PHASE III PLAN OF WORK

The following section describes the work plan, budget, and schedule for implementing the scope of work provided above for Phase III. The work plan assumes that SFPUC staff will manage the activities of a consultant team to prepare the next phase of the SFPUC Facilities Reliability Program.

4.1 Work Tasks and Costs

Project Coordination. Phase III of the SFPUC Facilities Reliability Program will be conducted by a project team consisting of SFPUC staff assisted by a consultant team. One project team member will serve as project director and will direct the consultant team and administer the consultant contract. The project director and consultant team will meet as frequently as required, usually twice a month, to review project progress, upcoming deliverables, and administrative matters.

General direction and oversight will be provided by a Joint Staff Working Group with regularly scheduled meetings or workshops. The Joint Staff Working Group will meet monthly to receive presentations on deliverables from the project team and consultant team; and for the Joint Staff Working Group to comment on project direction and deliverables, and provide oversight. Workshops identified in the scope of work above will occur at times when the key decisions are needed. These workshops will be concurrent with the monthly Joint Staff Working Group meeting and will be focused on the specific task or decisions being addressed. Attendance at the workshops is expected of the Project Team, the Joint Staff Working Group members, and other SFPUC/BAWUA staff or consultants as needed for the particular task being addressed.

Project Management Plan. A project management plan will be prepared, similar to the plan prepared for Phase II, to communicate the project process and administrative details to project participants. The project management plan will describe the background of the program and the results of the first two phases and provide the following information:

- Team Organization,
- Scope of Work,
- Deliverables,
- Budget and MBE/WBE Participation,
- Schedule, and
- Project Coordination and Communications.

Framework for Communications. Educating the public about the critical need of the overall program and individual components will be vital to help build support for and lessen opposition to future rate increases and to improve understanding of the project costs. As part of this, the SFPUC will need to explain and communicate the rigorous, sound approach used to prioritize projects and determine costs. This will allow the public within the entire SFPUC service area (including suburban users) to have input to the process of deciding the level of risk mitigation they expect their elected and appointed officials to select, and that they are willing to pay for.

The SFPUC is planning to hire a Program Manager in the next six months to oversee the entire Capital Improvement Program, which will include preparing a 15- to 20-year communications program to manage outreach needs on all major capital improvement projects. Communication activities for the Facilities Reliability Program would need to be consistent with the goals and integrated within the framework of the Program Management communications plan. To determine the arrangement between communication activities, it will be important to coordinate closely as the Program Manager's long-term communication program is defined to ensure efficient integration of the Facilities Reliability Program.

Appendix D provides a recommended framework for communications related to the Facilities Reliability Program. The communications framework identifies communication activities to implement during Phase III and Phase IV of the Facilities Reliability Program. The specific activities to be implemented in Phase IV will be developed during Phase III.

4.2 Phase III Schedule and Costs

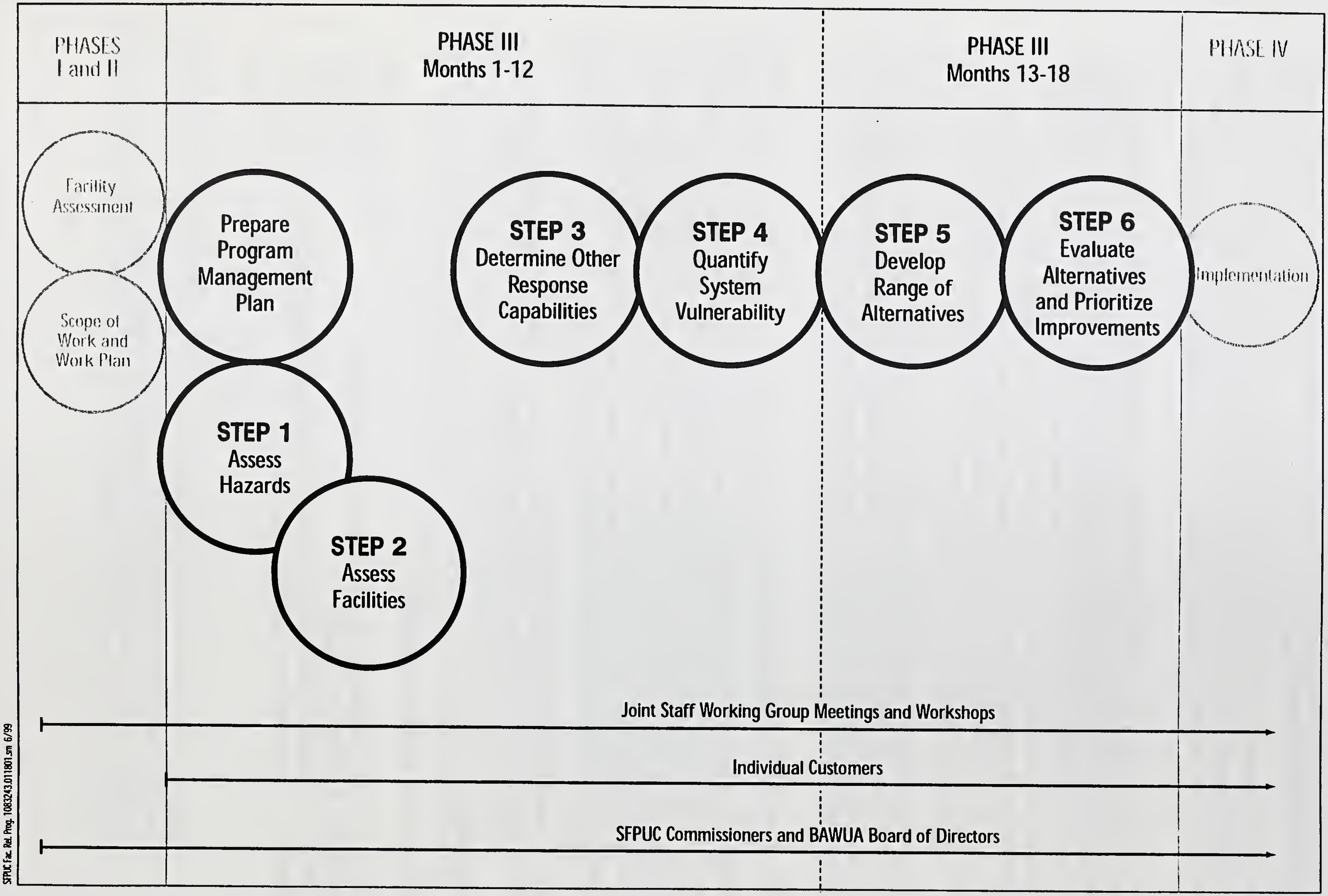
Schedule. The schedule for conducting the Phase III analysis is shown in Figure 2. The figure groups the work tasks according to the process steps identified in Figure 1 adding in the preparation of the program management plan and framework for communications. The schedule reflects nine workshops and two presentations each to the SFPUC Commissioners and the BAWUA Board of Directors. The schedule is based on completing Phase III of the Facilities Reliability Program within 18 months of the notice to proceed date.

Costs. The estimated cost of consulting services to support the Phase III effort based on the scope of work provided in Section 3.0 is $3.8 to 4.2 million.

5.0 Appendices

Attached are the following appendices.

Appendix A - Early Implementation Activities – Scopes of Work
Appendix B - Facilities Data Sheets
Appendix C - Example Scope of Work to Determine Customer System Demands
Appendix D - Framework for Communications


PHASES I and II
PHASE III Months 1-12
PHASE III Months 13-18
PHASE IV
Facility Assessment
Scope of Work and Work Plan
Prepare Program Management Plan
STEP 1 Assess Hazards
STEP 2 Assess Facilities
STEP 3 Determine Other Response Capabilities
STEP 4 Quantify System Vulnerability
STEP 5 Develop Range of Alternatives
STEP 6 Evaluate Alternatives and Prioritize Improvements
Implementation
Joint Staff Working Group Meetings and Workshops
Individual Customers
SFPUC Commissioners and BAWUA Board of Directors
SFPUC Fac. Rel. Prog. 1083243.011801.sm 6/99

SFPUC Facilities Reliability Program

Phase III Schedule

Figure 2

SFPUC Facilities Reliability Program
Phase II - Regional System Overview

SUBJECT:	Technical Memorandum No. 4 **Appendix A: Early Implementation Activities - Scopes of Work**
PREPARED BY:	The Water Reliability Partnership
DATE:	July 30, 1999

Early Implementation Projects

Scopes of Work

Cost estimates for the Early Implementation Projects are provided for preliminary planning only and are not intended to be precise since the projects are not defined in great detail. The estimates are based on broad assumptions and limited details due to the preliminary and uncertain nature of the projects. Actual tasks and the required level of effort for each task will not be fully defined until the projects are further developed. The cost estimates are based on experience with similar projects and broad assumptions about the nature of the work. Actual costs can be expected to vary from the estimated costs as details become known and the scopes of work change. It is recommended that cost estimates be updated periodically as the projects develop.

Scope of Work for Project EI-01

Project: New Bay Division Pipeline Replacing/Augmenting Bay Division Pipelines Nos. 1 and 2

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 174, Control No. 99; Project No. 119, Control No. 100; Project No. 179, Control No. 99012

Description: Bay Division Pipelines (BDPL's) Nos. 1 and 2 are the main source of supply for East Bay water providers including the City of Hayward and Alameda County Water District. These pipelines also provide water to the San Francisco Peninsula. Therefore, reliability of BDPL's Nos. 1 and 2 is critical. However, the pipelines appear to have significant reliability deficiencies. Due to their deteriorating condition, they are not likely to withstand seismic events occurring on nearby faults including the Hayward Fault, the Calaveras Fault, and the San Andreas Fault. Therefore, it is necessary to replace or augment BDPL's Nos. 1 and 2 with a new pipeline. The new pipeline will only be designed to increase the reliability of the system; it will not increase capacity. This project involves analyses of alternative configurations, design, and implementation of improvements to increase the reliability of water supply to customers in the East Bay and the San Francisco peninsula.

Project No. EI-01: New Bay Division Pipeline Replacing/Augmenting Bay Division Pipelines Nos. 1 and 2

Task	Scope of Work
Environmental & Permitting	1. Evaluate and rank environmental impacts of alternatives identified in preliminary design. 2. Develop project specific CEQA documentation. 3. Identify and obtain required permits. 4. Attend meetings and workshops.
Preliminary Design	1. Evaluate potential routes for a new pipeline. Rate alternative routes based on costs, environmental impacts, reliability advantages, hydraulics, and other applicable criteria. 2. Analyze hydraulics of the alternative routes including impacts to the existing system. Include

Project No. EI-01: New Bay Division Pipeline Replacing/Augmenting Bay Division Pipelines Nos. 1 and 2

Task	Scope of Work
	analysis of water delivery to East Bay customers in relation to pressurization of the Pulgas Tunnel. 3. Develop planning level cost estimates and layouts for the proposed alternatives. 4. Evaluate costs and benefits of abandoning or rehabilitating BDPL's Nos. 1 and 2 in lieu of or in addition to constructing BDPL No. 5. Evaluate structural and mechanical conditions of BDPL's Nos. 1 and 2 and potential modifications to withstand a PGA of 0.6 to 0.7 g. 5. Perform a risk analysis of the system including all existing and proposed bay division pipelines (Nos. 1 through 5). 6. Perform site-specific geotechnical investigations and analyses for the preferred project. 7. Evaluate costs and benefits of dividing the project into separate construction/procurement contracts. 8. Prepare an implementation schedule. 9. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. Design new and rehabilitated pipelines to withstand PGA of 0.6 to 0.7 g. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting(s), answering bid period questions from contractors, preparing and issuing addenda, attending bid opening(s), and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications.

Project No. EI-01: New Bay Division Pipeline Replacing/Augmenting Bay Division Pipelines Nos. 1 and 2

Task	Scope of Work
	4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Environmental Mitigation Monitoring. 8. Provide QA/QC materials testing. 9. Attend meetings/workshops.
Other	1. Conduct public relations program. 2. Project management.
Construction	1. Construction contract for new BDPL No. 5.
Estimated Capital Costs	**$ 331,000,000**

Scope of Work for Project EI-02

Project: Bay Division Pipelines Nos. 3 and 4 Cross Connections

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 135, Control No. 88

Description: Bay Division Pipelines (BDPL's) Nos. 3 and 4 are critical conduits for conveying water to the South Bay and the San Francisco peninsula. These pipelines cross liquefaction zones and fault that are potential points of pipe failures during a seismic event. Reliability of BDPL's Nos. 3 and 4 can be enhanced by constructing cross connections with appropriate valves that would allow water to be diverted from one pipeline to the other in the event of a pipe failure. Cross connection points would be located near the edges of fault and liquefaction zones (upstream and downstream of potential failure points). Thereby, capability to bypass pipe segments with the greatest potential for failure would be provided.

Project No. EI-02: Bay Division Pipelines Nos. 3 and 4 Cross Connections	
Task	**Scope of Work**
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Evaluate locations of potential cross connection points. It is assumed that four cross connections will be needed (one at each end of BDPL's Nos. 3 and 4 and one at each side of the liquefaction zone). 2. Develop construction sequencing guidelines assuming that connection will be made while pipes are in-service. 3. Develop preliminary layouts and cost estimates of the cross connections. 4. Perform a site-specific geotechnical investigation and analyses for the preferred project.

Project No. EI-02: Bay Division Pipelines Nos. 3 and 4 Cross Connections	
Task	**Scope of Work**
	5. Evaluate costs and benefits of dividing the project into separate construction/procurement contracts. 6. Prepare an implementation schedule. 7. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project(s). 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting(s), answering bid period questions from contractors, preparing and issuing addenda, attending bid opening(s), and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Conduct public relations program. 2. Project management.

Project No. EI-02: Bay Division Pipelines Nos. 3 and 4 Cross Connections	
Task	**Scope of Work**
Construction	1. Construction contract(s) for cross connections.
Estimated Capital Costs	**$ 6,600,000**

Scope of Work for Project EI-03

Project: Palo Alto Pipeline Connection

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 183, Control No. 124

Description: The current connection point of the Palo Alto Pipeline to the Bay Division Pipelines limits the flexibility to provide service to customers in Redwood City, Menlo Park, Atherton, and portions of unincorporated San Mateo County following a seismic event. The existing condition limits capability to perform repairs to BDPL's Nos. 1 and 2 between Valves A41 and B41 and between Valves A60 and B60. Additionally, a catastrophic failure of the two pipelines between these valves would severely limit water supply in these communities.

The existing Palo Alto pipeline would be extended to connect with BDPL's Nos. 3 and 4. The extension could be routed along Page Mill Road in Palo Alto. The existing pipe would also be improved or replaced to withstand PGA of 0.6 to 0.7 g.

Project No. EI-03: Palo Alto Pipeline Connection	
Task	**Scope of Work**
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Evaluate potential route of pipeline extension. Rate alternative routes based on costs, environmental impacts, reliability advantages, hydraulics, and other applicable criteria. 2. Develop preliminary design for new connection point, pipeline extension, and rehabilitation/replacement of existing pipe. 3. Develop construction sequencing guidelines assuming that connections will be made while pipes are

Project No. EI-03: Palo Alto Pipeline Connection	
Task	**Scope of Work**
	in-service. 4. Develop a preliminary cost estimate. 5. Perform site-specific geotechnical investigations and analyses for the preferred route. 6. Prepare an implementation schedule. 7. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project(s). 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting(s), answering bid period questions from contractors, preparing and issuing addenda, attending bid opening(s), and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Conduct public relations program.

Project No. EI-03: Palo Alto Pipeline Connection	
Task	**Scope of Work**
	2. Project management.
Construction	1. Construction contract for Palo Alto Pipeline
Estimated Capital Costs	**$ 46,000,000**

Scope of Work for Project EI-04

Project: Harry Tracy WTP Structural Analysis

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 165, Control No. 9938; Project No. 187, Control No. 276; Project No. 161, Control No. 103

Description: The Harry Tracy Water Treatment Plant (HTWTP) is a critical facility for delivering safe potable water to SFPUC customers. If the Hetch Hetchy and Calaveras supplies are disrupted and the Sunol WTP is not able to operate, the HTWTP will be the only remaining supply source of potable water. Therefore, it is critical that the HTWTP be able to withstand a seismic event and satisfy demand if water is not available from other sources. It may be necessary to upgrade the HTWTP to reliably treat up to 160 mgd to supply the entire existing demand of the SFPUC under the anticipated hazard scenario. This project also involves development of facilities to allow raw water from San Andreas Reservoir to bypass the HTWTP in the event that it is heavily damaged.

Project No. EI-04: Harry Tracy Water Treatment Plant Structural Analysis

Task	Scope of Work
Environmental & Permitting	1. Not included in project.
Preliminary Design	1. Evaluate structural integrity of buildings, tanks, yard piping, storage reservoirs, equipment, and chemical tank anchors. 2. Evaluate requirements to expand treatment reliable capacity to 160 mgd. 3. Perform site-specific geotechnical investigations and analyses. 4. Evaluate improvement options and perform risk analysis. 5. Develop a preliminary cost estimate. 6. Prepare an implementation schedule.

Project No. EI-04: Harry Tracy Water Treatment Plant Structural Analysis

Task	Scope of Work
	7. Attend meetings and workshops.
Final Design	1. Not included in project.
Construction Management	1. Not included in project.
Other	1. Project management.
Construction	1. Not included in project.
Estimated Capital Costs	**$ 410,000**

Scope of Work for Project EI-05

Project:	Pulgas Tunnel Pressure Improvements
Agency:	Water Supply and Treatment Division (WS&TD)
Related CIP Project:	Project No. 207, Control No. 9901

Description: The Pulgas Tunnel and Bypass Tunnel near Upper Crystal Springs Reservoir currently operate in an open channel flow condition or at very low pressurization. The overflow weir into Upper Crystal Springs Reservoir maintains this condition at most times.

Several operational problems exist with the current system. In order to make use of the balancing reservoir, continuous manipulation/throttling of the pumps and valves is required. When the South Bay is supplied from the Harry Tracy Water Treatment Plant, the pressure is limited such that some customers may not receive water. Most of these problems would be solved if the Pulgas Tunnel and Bypass Tunnel could operate at a pressure of about 30 feet of water column.

The Pulgas Tunnel and Bypass Tunnel were constructed by the Spring Valley Water Company in 1924 and 1969, respectively. Neither of these tunnels appears to have been designed to operate under pressurized conditions.

This project involves reviewing the pressure carrying capacity of the tunnels and design of improvements to increase the pressure capacity of the tunnels if necessary.

Project No. EI-05: Pulgas Tunnel Pressure Improvements	
Task	**Scope of Work**
Environmental & Permitting	1. Not included in project.
Preliminary Design	1. Inspect the tunnels and assess their conditions. 2. Assess feasibility of pressurization of Pulgas Tunnel. 3. Assess the structural integrity of tunnel to withstand PGA of 0.5 to 0.6 g. If deficient, evaluate

Project No. EI-05: Pulgas Tunnel Pressure Improvements	
Task	**Scope of Work**
	improvement alternatives including parallel tunnel or bypass pipeline (alignment study), strengthening/improving the existing tunnels, and improving repair capability. 4. Perform a risk analysis and evaluate costs/benefits of improvement alternatives. 5. Prepare an implementation schedule. 6. Attend meetings and workshops.
Final Design	1. Not included in project.
Construction Management	1. Not included in project.
Other	1. Project management.
Construction	1. Not included in project.
Estimated Capital Costs	**$ 440,000**

Scope of Work for Project EI-06

Project: Harry Tracy WTP Backfeed Capability Analyses

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 165, Control No. 9938; Project No. 187, Control No. 276; Project No. 161, Control No. 103; Project No. 207, Control No. 9901

Description: The Hetch Hetchy and Sunol WTP supplies are currently the only sources of potable water for the customers in the South Bay and East Bay. If these supplies are disrupted, most of the customers will be without water. Therefore, it may be necessary to provide a backup source by adding capability to feed potable water from the Harry Tracy WTP backwards through the bay division pipelines to customers in the South Bay and East Bay. This project involves studying the feasibility of backfeeding water from the HTWTP as far as Hayward. The project augments Projects EI-04, EI-05, and EI-07 by providing a thorough regional system analysis of backfeeding capability.

Project No. EI-06: Harry Tracy WTP Backfeed Capability Analyses	
Task	**Scope of Work**
Environmental & Permitting	1. Not included in project.
Preliminary Design	1. Perform hydraulic analyses to identify restrictions that limit ability to backfeed from the HTWTP. 2. Develop alternatives to remove flow restrictions. Determine whether or not backfeeding from HTWTP is feasible. 3. Perform cost/benefits analysis to balance the need for emergency service against limited funds. 4. Develop cost estimates for recommended improvements. 5. Prepare an implementation schedule. 6. Attend meetings and workshops.
Final Design	1. Not included in project.

Project No. EI-06: Harry Tracy WTP Backfeed Capability Analyses	
Task	**Scope of Work**
Construction Management	1. Not included in project.
Other	1. Project management.
Construction	1. Not included in project.
Estimated Capital Costs	**$ 440,000**

Scope of Work for Project EI-07

Project: Capuchino Valve Lot Capacity Improvements

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 135, Control No. 88

Description: As described under Project Nos. EI-05 and EI-06, it is desirable to provide capability to backfeed potable water from the Harry Tracy WTP through the Bay Division Pipelines to customers in the East Bay and South Bay. The Capuchino Valve Lot is a critical element to permit backfeeding from the Harry Tracy WTP and pressurization of the Pulgas Tunnel. This project involves analyzing the Capuchino Valve lot to determine what improvements are needed to provide up to 80 mgd of backfeed capability and implementation of the recommended improvements. Improvements to increase the seismic reliability of the valve lot are also included in this project.

Project No. EI-07: Capuchino Valve Lot Capacity Improvements

Task	Scope of Work
Environmental & Permitting	1. Develop project specific CEQA documentation if needed. 2. Identify and obtain required permits, if any.
Preliminary Design	1. Review existing drawings and specifications. 2. Perform site specific geotechnical investigations and analyses. 3. Perform analyses to identify restrictions that limit ability to backfeed from the HTWTP through the Capuchino Valve Lot. 4. Develop alternatives to remove flow restrictions. Determine whether or not backfeeding from HTWTP is feasible. 5. Evaluate structural and mechanical conditions of the facility. Develop alternatives to improve the valve lot to withstand PGA of 0.5 to 0.6 g.

Project No. EI-07: Capuchino Valve Lot Capacity Improvements

Task	Scope of Work
	6. Develop cost estimates for recommended improvements. 7. Prepare an implementation schedule. 8. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.
Construction	1. Construction contract for valve lot improvements.

Project No. EI-07: Capuchino Valve Lot Capacity Improvements	
Task	**Scope of Work**
Estimated Capital Costs	$ 960,000

Scope of Work for Project No. EI-08

Project: Irvington Tunnel Reliability Improvements

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: N/A

Description: The Irvington Tunnel is the only conduit available to convey water from Hetch Hetchy and the Sunol WTP and the Bay Division Pipelines. Therefore, the tunnel and its portal are critical for system reliability. This project involves increasing the reliability of the tunnel (especially the west portal) to survive PGA's of 0.6 to 0.7 g, providing bypass capability, or providing means to repair the tunnel/portal within 30 days of a seismic event.

Project No. EI-08: Irvington Tunnel Reliability Improvements	
Task	**Scope of Work**
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.

Project No. EI-08: Irvington Tunnel Reliability Improvements

Task	Scope of Work
Preliminary Design	1. Review existing drawings and specifications. 2. Perform site specific geotechnical investigations and analyses. 3. Perform inspections of the tunnel/portal. 4. Develop alternatives to increase the strength of the tunnel and/or west portal to withstand the design seismic event. 5. Develop alternatives to bypass the tunnel/portal via a parallel conduit possibly routed through Niles Canyon. 6. Develop alternatives to provide capability to repair damage to the tunnel/portal within 30 to 60 days. 7. Select alternatives for implementation based on costs, environmental impacts, reliability improvements, hydraulics, and other applicable criteria. 8. Develop cost estimates for recommended improvements. 9. Prepare an implementation schedule. 10. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.

Project No. EI-08: Irvington Tunnel Reliability Improvements

Task	Scope of Work
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.
Construction	1. Construction contract for tunnel/portal improvements or bypass conduit.
Estimated Capital Costs	**$ 63,100,000**

Scope of Work for Project EI-09

Project: Crystal Springs Pump Station and Crystal Springs-San Andreas Pipeline Capacity Improvements

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: GET FROM EVERETT HINGTZE

Description: If the Hetch Hetchy and Sunol WTP supplies are disrupted, water from the Crystal Springs and San Andreas Reservoirs and treatment at the Harry Tracy WTP will become more critical. Therefore, it will be necessary to improve the raw water feed capacity and reliability from the San Andreas Reservoir and the Crystal Springs Reservoir to the Harry Tracy WTP. Since feed water to the HTWTP cannot be drawn directly from Crystal Springs Reservoir, it is necessary to first transfer water from Crystal Springs to San Andreas via the Crystal Springs Pump Station and the Crystal Springs-San Andreas Pipeline. This project involves increasing the capacity of the Crystal Springs Pump Station and the Crystal Springs-San Andreas Pipeline to 144 mgd. The project also involves increasing the seismic reliability of these facilities and the pipeline from San Andreas Reservoir to the HTWTP.

Project No. EI-09: Crystal Springs Pump Station and Crystal Springs-San Andreas Pipeline Capacity Improvements

Task	Scope of Work
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Review existing drawings and specifications. 2. Perform site specific geotechnical investigations and analyses. 3. Perform inspections of the facilities. 4. Develop alternatives to increase the capacity of the pump station and pipeline. 5. Develop alternatives to increase the seismic reliability of the pump station to withstand PGA's of 0.6

Project No. EI-09: Crystal Springs Pump Station and Crystal Springs-San Andreas Pipeline Capacity Improvements

Task	Scope of Work
	to 0.7 g. 6. Develop alternatives to increase the seismic reliability of the pipeline to withstand PGA's of 0.6 to 0.7 g. Evaluate use of flexible and restrained joints to improve seismic reliability of the pipeline. Evaluate construction of a parallel pipeline to improve reliability. 7. Select alternatives for implementation based on costs, environmental impacts, reliability improvements, hydraulics, and other applicable criteria. 8. Develop cost estimates for recommended improvements. 9. Prepare an implementation schedule. 10. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers.

Project No. EI-09: Crystal Springs Pump Station and Crystal Springs-San Andreas Pipeline Capacity Improvements

Task	Scope of Work
	7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.
Construction	1. Construction contract for pump station and pipeline improvements.
Estimated Capital Costs	**$ 43,000,000**

Scope of Work for Project EI-10

Project: Santa Clara Valley Water District Intertie

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 131, Control No. 269

Description: This project will provide facilities for an interie between the Santa Clara Valley Water District (SCVWD) and San Francisco's PUC water supply systems. The interite will provide up to 40 mgd in either direction. It is intended to provide water for health and safety needs in the event of major facility failures, to provide a sole source of supply during planned pipeline shutdowns of certain segments of the system for inspections and repairs, and to provide the capability for wheeling of water to overcome shortages. The project will also involve assessing needs for pumping water through the pipeline or whether gravity flow will be possible.

SCVWD has already completed projects estimated at $5.8 million to provide capacity in its water supply system to allow for the intertie. The PUC and SCVWD have each approved the project in concept and authorized negotiations toward and agreement to build the facility. Total costs are to be shared evenly between the PUC and SCVWD.

Project No. EI-10: Santa Clara Valley Water District Intertie

Task	Scope of Work
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Evaluate potential routes for the new intertie pipeline. Develop preliminary layouts for the alternatives. 2. Analyze hydraulics of the alternative routes. Evaluate needs for pumping. 3. Develop planning level cost estimates and layouts for the proposed alternatives.

Project No. EI-10: Santa Clara Valley Water District Intertie	
Task	**Scope of Work**
	4. Perform site specific geotechnical investigations and analyses. 5. Select an alternative for implementation based on costs, environmental impacts, reliability improvements, hydraulics, and other applicable criteria. 6. Develop cost estimates for recommended improvements. 7. Prepare an implementation schedule. 8. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.

Project No. EI-10: Santa Clara Valley Water District Intertie	
Task	**Scope of Work**
Other	2. Project management.
Construction	4. Construction contract for intertie pipeline improvements.
Estimated Capital Costs	**$ 22,000,000**

Scope of Work for Project EI-11

Project: All Critical Facilities – Structural, Geotechnical, and Other Assessments (Regional System)

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: N/A

Description: This project involves identification and assessment of reliability deficiencies in all critical facilities. Geotechnical, structural, and general reliability investigations and assessments will be conducted for each facility. Facility vulnerabilities and obvious improvements will be identified.

Project No. EI-11: All Critical Facilities – Structural, Geotechnical, and Other Assessments (Regional System)	
Task	**Scope of Work**
Environmental & Permitting	1. Not included in project.
Preliminary Design	1. Conduct geotechnical investigations and evaluations at all sites. 2. Conduct structural investigations and evaluations at all sites.
Final Design	1. Not included in project.
Construction Management	1. Not included in project.
Other	1. Project management.
Construction	1. Not included in project.
Estimated Capital Costs	**$ 2,460,000**

Scope of Work for Project No. EI-12

Project: Pipeline Repair Prioritization Plan (Regional System)

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: N/A

Description: This project involves development of a response plan for major seismic events. The response plan will include a detailed priority list of critical facilities that may be damaged during a seismic event. The priority list will identify the order in which facilities should be repaired to restore service to the maximum number of customers in the shortest time frame possible. The plan will also list materials and equipment that should be stockpiled to make the repairs on short notice.

CHECK FOR EXISTING PLAN. PUC HAS OVERALL EMERGENCY PLAN. NOT SPECIFIC TO WATER. OPERATING DIVISIONS SHOULD ALSO HAVE PLANS. OCC IS DEVELOPING PLAN FOR WS&TD. CDD HAS "BLUE BOOK". HETCH HETCHY HAS EMERGENCY PLAN ALSO.

Project No. EI-12: Pipeline Prioritization Plan (Regional System)	
Task	**Scope of Work**
Environmental & Permitting	2. Not included in project.
Preliminary Design	1. Analyze system to identify critical facilities at risk of damage during a seismic event. 2. Develop a detailed repair prioritization plan. 3. Develop a detailed list of materials and equipment needed to make emergency repairs. 4. Attend meetings and workshops.
Final Design	2. Not included in project.
Construction	2. Not included in project.

Project No. EI-12: Pipeline Prioritization Plan (Regional System)	
Task	**Scope of Work**
Management	
Other	2. Project management.
Construction	2. Not included in project.
Estimated Capital Costs	**$ 150,000**

Scope of Work for Project EI-13

Project:	Sunset and University Mound Reservoirs – Reservoir Roof Reinforcement
Agency:	Water Supply and Treatment Division (WS&TD)
Related CIP Project:	Project No. 654, Control No. 9960; Project No. ____, Control No. 99083

Description: The roof of the North Basin of Sunset Reservoir has the highest priority of all the City reservoirs for seismic retrofitting. The reservoir roof was constructed in 1938 and besides being seismically deficient; the concrete roof has spalled in many locations. This project will fund conceptual engineering, detail design, and construction for seismic retrofit and general repair of the structure. The PUC has authorized recreational use on the reservoir roof and it is possible that a portion of the roof will be reconstructed to support additional loading from recreational use.

The functional analysis for conceptual engineering of the seismic upgrade has been completed and design is underway using a $650,000 appropriation approved in FY 1997-98.

Similar seismic improvements will be required at the University Mound Reservoir. The University Mound Reservoir is particularly vulnerable because it does not have an adequate back-up facility. This project will involve investigations, development of rehabilitation alternatives, and implementation of reliability improvements.

Project No. EI-13: Sunset and University Mound Reservoirs – Reservoir Roof Reinforcement	
Task	**Scope of Work**
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Review record drawings and specifications. 2. Inspect the facilities including structural, mechanical, and electrical systems. 3. Perform site specific geotechnical investigations and analyses.

Project No. EI-13: Sunset and University Mound Reservoirs – Reservoir Roof Reinforcement

Task	Scope of Work
	4. Develop recommendations for rehabilitation to withstand PGA of 0.6 to 0.7 g at Sunset Reservoir and PGA of 0.4 to 0.5 g at University Mound Reservoir. 5. Develop planning level cost estimates for the proposed alternatives. 6. Prepare an implementation schedule. 7. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.

Project No. EI-13: Sunset and University Mound Reservoirs – Reservoir Roof Reinforcement	
Task	**Scope of Work**
Construction	1. Construction contract for Sunset Reservoir and University Mound Reservoir rehabilitation.
Estimated Capital Cost	**$ 36,700,000**

Scope of Work for Project EI-14

Project: Crystal Springs Pipeline No. 1 Construction (Project Already Underway)

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 112, Control No. 156

Description: Crystal Springs Pipeline No. 1 (CSPL #1) was built in the 1880's and is beyond its life expectancy. The pipeline has extensive leaks that do not permit it to be put back into service. Consequently, only Crystal Springs Pipeline #2 (CSPL #2), which was built in the 1930's, is available to convey flow to the University Mound Reservoir. University Mound Reservoir is the main water supply source for all of eastern San Francisco. If CSPL #2 fails, there is no backup supply system except for cross town feeds that can only supply a small fraction of the total demand.

Replacement of parts of CSPL #1 is critical to assure reliable water supply to eastern San Francisco. This project will replace approximately 13,300 feet of existing pipe with new steel pipe. Final design was scheduled for completion in 1997.

Previous appropriations for this project were used to design and construct two sections of the pipeline and to design the section to be replaced under Phase II and to fund a portion of the Phase II construction. Funds being requested in FY 1999-00 are for the remainder of construction and construction inspection. To date, $10,560,000 has been appropriated for this project of which $9,000,000 has been allocated to the construction work. It is assumed that CEQA documentation has been completed for this project.

Project No. EI-14: Crystal Springs Pipeline No. 1 Construction (Project Already Underway)	
Task	Scope of Work
Environmental & Permitting	1. Identify and obtain required permits. 2. Attend meetings and workshops.
Preliminary Design	1. Complete review of record drawings and specifications. 2. Perform site specific geotechnical investigations and analyses for remaining sections.

Project No. EI-14: Crystal Springs Pipeline No. 1 Construction (Project Already Underway)

Task	Scope of Work
	3. Develop planning level cost estimates for the proposed alternatives. 4. Prepare an implementation schedule. 5. Attend meetings and workshops.
Final Design	1. Complete construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.
Construction	1. Construction contract for remainder of Crystal Springs Pipeline No. 1.

Project No. EI-14: Crystal Springs Pipeline No. 1 Construction (Project Already Underway)	
Task	**Scope of Work**
Estimated Capital Cost	**$ 6,200,000**

Scope of Work for Project EI-15

Project: Baden Pump Station Improvements

Agency: Water Supply and Treatment Division (WS&TD)

Related CIP Project: Project No. 151, Control No. 9966

Description: Baden Pump Station conveys water from Crystal Springs Pipeline No. 2 and the Sunset Supply Pipeline to San Andreas Pipeline No. 2 and ultimately to customers in Daly City, California Water Company, and high zones in the CDD service area. This pump station is an important facility for conveying Hetch Hetchy water to CDD high zones if the Crystal Springs Pump Station and HTWTP are disrupted due to a seismic event on the San Andreas Fault. This project involves evaluating, designing, and implementing improvements to increase the reliability of the pump station.

Project No. EI-15: Baden Pump Station Improvements	
Task	**Scope of Work**
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Review existing drawings and specifications. 2. Perform site specific geotechnical investigations and analyses. 3. Evaluate structural and mechanical conditions of the facility. Develop alternatives to improve the pump station to withstand PGA of 0.6 to 0.7 g. 4. Develop cost estimates for recommended improvements. 5. Prepare an implementation schedule.

Project No. EI-15: Baden Pump Station Improvements	
Task	**Scope of Work**
	6. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project.
	2. Prepare 10%, 50%, and 100% cost estimates and schedules.
	3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations.
	4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions.
	2. Review and respond to shop drawings (submittals) and requests for information.
	3. Issue design clarifications.
	4. Review and negotiate change orders.
	5. Review contractor's schedule and progress billings.
	6. Conduct on-site construction inspection and field visits by engineers.
	7. Provide QA/QC materials testing.
	8. Attend meetings/workshops.
Other	1. Project management.
Construction	1. Construction contract for valve lot improvements.
Estimated Capital Costs	**$ 2,200,000**

Scope of Work for Project EI-16

Project: North Area of City – Additional Storage

Agency: City Distribution Division (CDD)

Related CIP Project: Project No. _____, Control No. 99077

Description: Additional storage capacity is needed to assure an adequate water supply to customers in the northeast and northwest portions of the City in the event that other supplies are disrupted by a seismic event. This project involves studying, designing, and constructing additional storage capacity by rebuilding Francisco Reservoir at a higher elevation or adding storage near the Presidio. This project is in addition to planned construction of Balboa Reservoir. Added storage capacity will be linked to the backbone pipeline project that will provide means to convey water between the northwest and northeast portions of the City.

Project No. EI-16: North Area of City – Additional Storage	
Task	**Scope of Work**
Environmental & Permitting	1. Evaluate and rank environmental impacts of alternatives identified in preliminary design. 2. Develop project specific CEQA documentation. 3. Identify and obtain required permits. 4. Attend meetings and workshops.
Preliminary Design	1. Review record drawings and specifications of the Francisco Reservoir. 2. Inspect the facilities at the Francisco Reservoir including structural, mechanical, and electrical systems. 3. Evaluate costs and benefits of rebuilding Francisco Reservoir versus building new storage near the Presidio. Select the best alternative based on costs, environmental impacts, hydraulics, reliability advantages, and other applicable criteria.

Project No. EI-16: North Area of City – Additional Storage	
Task	**Scope of Work**
	4. Perform site specific geotechnical investigations and analyses at the chosen site. 5. Develop planning level cost estimates for the proposed alternative. 6. Prepare an implementation schedule. 7. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.

<table>
<tr><th colspan="2">Project No. EI-16: North Area of City – Additional Storage</th></tr>
<tr><th>Task</th><th>Scope of Work</th></tr>
<tr><td>Construction</td><td>1. Construction contract for added storage in the northern area of San Francisco.</td></tr>
<tr><td>Estimated Capital Cost</td><td>$ 47,200,000</td></tr>
</table>

Scope of Work for Project EI-17

Project: College Hill and Summit Reservoirs – Reservoir Roof Reinforcement

Agency: City Distribution Division (CDD)

Related CIP Project: Project No. ____, Control No. 99083

Description: College Hill and Summit Reservoirs are critical elements for maintaining water quality in the distribution system after a seismic event. This project involves completing site surveys, and internal and external inspection on the College Hill and Summit Reservoirs. The inspection will focus on seismic reliability, corrosion, and other areas where failures might occur. Flexible connections will be evaluated to replace rigid connections between such items as piping and tanks. Reservoir roofs will be inspected and evaluated for seismic design. As-built drawings will be developed as part of this project.

Roof seals and expansion joints will be investigated for deterioration and leaks. Repair and replacement of seals and expansion joints will be evaluated to protect finished water from contamination and improve operation of the reservoirs.

Design drawings and construction contracts will be issued to rehabilitate the reservoirs based on the findings of the study.

Project No. EI-17: College Hill and Summit Reservoirs – Reservoir Roof Reinforcement

Task	Scope of Work
Environmental & Permitting	1. Develop project specific CEQA documentation. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Develop record drawings and specifications. 2. Inspect the facilities including structural, mechanical, and electrical systems.

Project No. EI-17: College Hill and Summit Reservoirs – Reservoir Roof Reinforcement	
Task	Scope of Work
	3. Perform site specific geotechnical investigations and analyses. 4. Develop recommendations for rehabilitation to withstand PGA of 0.6 to 0.7 g at Summit Reservoir and PGA of 0.4 to 0.5 g at College Hill Reservoir. 5. Develop planning level cost estimates for the proposed alternatives. 6. Prepare an implementation schedule. 7. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.

Project No. EI-17: College Hill and Summit Reservoirs – Reservoir Roof Reinforcement	
Task	**Scope of Work**
Other	2. Project management.
Construction	2. Construction contract for Summit Reservoir and College Hill Reservoir rehabilitation.
Estimated Capital Cost	**$ 29,300,000**

Scope of Work for Project EI-18

Project: Lake Merced Emergency Supply Improvements

Agency: City Distribution Division (CDD)

Related CIP Project: N/A

Description: Lake Merced may be connected to the distribution system (via a standby treatment facility) to increase the emergency supply of potable water within San Francisco. If Lake Merced water is available, the reliability of the system will be greatly increased. Improvements to permit use of Lake Merced water after a catastrophic emergency include lowering the intake structure at the lake, constructing standby treatment facilities to process up to 20 mgd, and constructing pipelines and pumping facilities to convey the water into the system. Treatment facilities would likely include pressure filters, membrane filtration, disinfection, and other chemical systems required by the process.

Project No. EI-18: Lake Merced Emergency Supply Improvements

Task	Scope of Work
Environmental & Permitting	1. Evaluate and rank environmental impacts of alternatives identified in preliminary design. 2. Develop project specific CEQA documentation. 3. Identify and obtain required permits. 4. Attend meetings and workshops.
Preliminary Design	1. Inspect the facilities at the lake including structural, mechanical, and electrical systems. 2. Perform site specific geotechnical investigations and analyses. 3. Evaluate feasibility, location, and alternative treatment processes required to treat water from Lake Merced. 4. Evaluate options for lowering the intake at Lake Merced. 5. Evaluate alternatives for conveying raw and treated water from Lake Merced to the treatment facility

Project No. EI-18: Lake Merced Emergency Supply Improvements	
Task	**Scope of Work**
	and from the treatment facility to the distribution system. 6. Select the best alternatives based on costs, environmental impacts, hydraulics, reliability advantages, and other applicable criteria. 7. Develop planning level cost estimates for the proposed alternatives. 8. Prepare an implementation schedule. 9. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.

Project No. EI-18: Lake Merced Emergency Supply Improvements

Task	Scope of Work
Other	1. Project management. 2. Public Relations Program.
Construction	1. Construction contract for Lake Merced emergency supply facilities.
Estimated Capital Cost	**$ 155,200,000**

Scope of Work for Project EI-19

Project: Groundwater Master Plan Implementation

Agency: City Distribution Division (CDD)

Related CIP Project: N/A

Description: The San Francisco Groundwater Master Plan (draft, July 1996) summarizes the PUC's plans to evaluate, manage, and develop its groundwater resources and to integrate the potable and non-potable use of groundwater for the benefit of its customers. The Master Plan identifies specific actions to be conducted during the subsequent 5 years and outlines broader strategies for the next 20 years. The Groundwater Master Plan was developed in conjunction with the Recycled Water Master Plan. Both documents went through CEQA documentation (certification, August 1997). The Groundwater Master Plan recommended numerous programs and projects to protect and use groundwater, including development of groundwater protection and saltwater intrusion prevention programs, installation of new production wells, and formation of a groundwater unit within the SFPUC. Implementation of this plan will result in an increase of water supply to the City. This program will also integrate the water supply with the CDD system during an emergency.

Project No. EI-19: Groundwater Master Plan Implementation	
Task	**Scope of Work**
Environmental & Permitting	1. Develop project specific CEQA documentation. A program EIR has already been completed for this project. 2. Identify and obtain required permits. 3. Attend meetings and workshops.
Preliminary Design	1. Conduct preliminary pumping and hydrogeology testing. 2. Develop alternatives for groundwater production wells and treatment facilities. 3. Evaluate alternatives in terms of costs, environmental impacts, hydraulics, reliability advantages, and

Project No. EI-19: Groundwater Master Plan Implementation	
Task	Scope of Work
	other applicable criteria. 4. Develop planning level cost estimates. 5. Develop an implementation schedule. 6. Attend meetings and workshops.
Final Design	1. Prepare construction drawings and specifications for the recommended project. 2. Prepare 10%, 50%, and 100% cost estimates and schedules. 3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations. 4. Attend meetings and workshops.
Construction Management	1. Attend pre-construction workshops/partnering sessions. 2. Review and respond to shop drawings (submittals) and requests for information. 3. Issue design clarifications. 4. Review and negotiate change orders. 5. Review contractor's schedule and progress billings. 6. Conduct on-site construction inspection and field visits by engineers. 7. Provide QA/QC materials testing. 8. Attend meetings/workshops.
Other	1. Project management.

Project No. EI-19: Groundwater Master Plan Implementation	
Task	**Scope of Work**
Construction	1. Construction contracts for the groundwater master plan implementation.
Estimated Capital Cost	**$ 18,000,000**

Scope of Work for Project No. EI-20

Project: Backbone Pipeline System Development

Agency: City Distribution Division (CDD)

Related CIP Project: N/A

Description: A backbone distribution system is needed to assure that an adequate water supply can be conveyed to customers in the most vulnerable parts of the City (north waterfront and downtown areas of University Mound Reservoir) immediately following a seismic event and when the regional is unavailable to the CDD. This project involves studying, designing, and constructing a backbone pipeline system to convey water from the regional system supply facilities to new storage facilities in the northern area of the City to customers across the north and northeast portions of the City. The pipeline could be implemented by reconstructing strategic sections of existing pipelines to increase their capacities. Hydraulic modeling will be conducted to identify bottlenecks that prevent adequate flow between the northeast and northwest. Alternatively, entirely new pipeline segments could be constructed to make up the backbone system.

<table>
<tr><th colspan="2">Project No. EI-20: Backbone Pipeline System Development</th></tr>
<tr><th>Task</th><th>Scope of Work</th></tr>
<tr><td>Environmental & Permitting</td><td>1. Evaluate and rank environmental impacts of alternatives identified in preliminary design.
2. Develop project specific CEQA documentation.
3. Identify and obtain required permits.
4. Attend meetings and workshops.</td></tr>
<tr><td>Preliminary Design</td><td>1. Evaluate alternative routes for the backbone pipeline.
2. Evaluate costs and benefits of each alternative. Select the best alternative based on costs, environmental impacts, hydraulics, reliability advantages, and other applicable criteria.</td></tr>
</table>

<table>
<tr><th colspan="2">Project No. EI-20: Backbone Pipeline System Development</th></tr>
<tr><th>Task</th><th>Scope of Work</th></tr>
<tr><td></td><td>3. Perform site specific geotechnical investigations and analyses along the chosen route.
4. Develop planning level cost estimates for the proposed alternative.
5. Prepare an implementation schedule.
6. Attend meetings and workshops.</td></tr>
<tr><td>Final Design</td><td>1. Prepare construction drawings and specifications for the recommended project.
2. Prepare 10%, 50%, and 100% cost estimates and schedules.
3. Provide bid period assistance including attending pre-bid meeting, answering bid period questions from contractors, preparing and issuing addenda, attending bid opening, and bid evaluations.
4. Attend meetings and workshops.</td></tr>
<tr><td>Construction Management</td><td>1. Attend pre-construction workshops/partnering sessions.
2. Review and respond to shop drawings (submittals) and requests for information.
3. Issue design clarifications.
4. Review and negotiate change orders.
5. Review contractor's schedule and progress billings.
6. Conduct on-site construction inspection and field visits by engineers.
7. Provide QA/QC materials testing.
8. Attend meetings/workshops.</td></tr>
<tr><td>Other</td><td>1. Project management.</td></tr>
</table>

Project No. EI-20: Backbone Pipeline System Development	
Task	**Scope of Work**
Construction	1. Construction contract for the backbone pipeline.
Estimated Capital Cost	**$ 25,200,000**

Scope of Work for Project No. EI-21

Project: Pipeline Repair Prioritization Plan (City Distribution System)

Agency: City Distribution Division (CDD)

Related CIP Project: N/A

Description: This project involves development of a response plan for major seismic events. The response plan will include a detailed priority list of critical facilities that may be damaged during a seismic event. The priority list will identify the order in which facilities should be repaired to restore service to the maximum number of customers in the shortest time frame possible. The plan will also list materials and equipment that should be stockpiled to make the repairs on short notice.

Project No. EI-21: Pipeline Prioritization Plan (City Distribution System)	
Task	**Scope of Work**
Environmental & Permitting	1. Not included in project.
Preliminary Design	1. Analyze system to identify critical facilities at risk of damage during a seismic event. 2. Develop a detailed repair prioritization plan. 3. Develop a detailed list of materials and equipment needed to make emergency repairs. 4. Attend meetings and workshops.
Final Design	1. Not included in project.
Construction Management	1. Not included in project.
Other	1. Project management.

Project No. EI-21: Pipeline Prioritization Plan (City Distribution System)

Task	Scope of Work
Construction	1. Not included in project.
Estimated Capital Costs	**$ 150,000**

Scope of Work Project No. EI-22

Project: All Critical Facilities – Structural, Geotechnical, and Other Assessments (most already conducted)

Agency: City Distribution Division (CDD)

Related CIP Project; N/A

Description: This project involves identification and assessment of reliability deficiencies in facilities included in Phase III of the reliability program that are not otherwise identified as early implementation projects. Geotechnical, structural, and general reliability investigations and assessments will be conducted for each facility. Recommended improvements will be presented for implementation under separate projects.

Project No. EI-22: All Critical Facilities – Structural, Geotechnical, and Other Assessments (City Distribution System)	
Task	**Scope of Work**
Environmental & Permitting	1. Not included in project.
Preliminary Design	1. Conduct geotechnical investigations and evaluations at all sites. 2. Conduct structural investigations and evaluations at all sites.
Final Design	1. Not included in project.
Construction Management	1. Not included in project.
Other	1. Project management.
Construction	1. Not included in project.
Estimated Capital Costs	**$ 2,820,000**

SFPUC Facilities Reliability Program Phase II – Regional System Overview

SUBJECT:	Technical Memorandum No. 4 **Appendix B: Critical Facility Data Sheets**
PREPARED BY:	The Water Reliability Partnership
DATE:	July 30, 1999

Table of Contents

HETCH HETCHY WATER AND POWER FACILITIES:

Chlorination Stations
- Tesla Portal
- Rock River Lime Plant

Dams/Reservoirs:
- Early Intake / Bypass
- O'Shaughnessy (Hetch Hetchy)
- Priest
- Upper Moccasin Creek Dam
- Moccasin Dam/Reservoir
- Lake Eleanor Dam/Reservoir
- Cherry Dam and Reservoir

Pipelines
- San Joaquin Pipeline Nos. 1, 2, & 3

Power Houses
- Holm
- Kirkwood
- Moccasin

Tunnels
- Canyon Power
- Coast Range
- Foothill/Red Mountain Bar Siphon/Oakdale Portal
- Mountain
- Priest Outlet and Moccasin Power Tunnel

Valve Houses
- Cherry Valve House

WATER SUPPLY AND TREATMENT DIVISION FACILITIES:

Dams/Reservoirs:
- Calaveras Dam/Reservoir
- Crystal Springs Dam/Reservoir
- San Andreas Dam/Reservoir
- Turner Dam/San Antonio Reservoir
- Pilarcitos Dam/Reservoir/Aqueduct

Pipelines

- Alameda Siphons
- Bay Division #1 and #2 (between Irvington Portal and Newark Valve Lot)
- Bay Division #1 and #2 (west of Ravenswood Valve Lot)
- Bay Division #3 and #4
- Crystal Springs Bypass
- Crystal Springs Pipeline No. 1, 2, 3 and 3 extension
- Crystal Springs – San Andreas
- Palo Alto
- San Andreas No. 1, 2 and 3
- Sunset Supply
- Calaveras

Pump Station

- Baden
- Crystal Springs
- Pulgas/Crystal Springs Balancing Reservoir
- San Antonio

Service Connections

Tunnels

- Crystal Springs Bypass
- Hillsborough
- Irvington
- Pulgas
- Stanford

Valve Lots

Water Treatment Plants

- Harry Tracy
- Sunol Valley

CITY DISTRIBUTION DIVISION FACILITIES:

Covered Reservoirs

- Sunset
- University Mound
- Sutro
- Summit
- College Hill
- Stanford Heights
- Merced Manor

Hydropneumatic Pump Stations

- Crocker Amazon
- Vista Francisco
- Palo Alto
- Forest Hill
- Lincoln Park
- Skyview – Aqua Vista
- Forest Knolls

Pipelines:

- Crosstown Pipeline

Pump Stations:

- Alemany
- Central
- Lake Merced
- Others: Mt. Davidson
  - Potrero Heights
  - Summit
  - McLaren
  - LaGrande
  - Bernal Heights

Tanks

- Mt. Davidson
- Lincoln Park
- Forest Hill (100,000 gal)
- Potrero Heights
- LaGrande
- Forest Hill (300,000 gal)
- Forest Knolls
- McLaren

Facility: Tesla Portal Chlorination Station

Description: Constructed in 1937.

Hazard Event: Worst case seismic event:
Great Valley (6.7 magnitude, PGA 0.4 – 0.5)
Seismic event following which the facility must remain operable:
San Andreas Fault (7.9 magnitude, PGA 0.1-0.2)

Critical Function: This is the major disinfection facility for Hetch Hetchy water.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 260 mgd	• 260 mgd	• None
Structural	• Withstand a minimum of PGA 0.4-0.5 or meet Building Code requirements	• To be determined	• To be determined
Mechanical / Electrical	• Equipment and storage tanks to withstand PGA 0.4-0.5 or meet code requirements • Standby power	• To be determined • To be determined	• To be determined • To be determined
Security	• Automatic surveillance • Fire suppression • System	• Station is attended part time • To be determined	• Automatic surveillance system • To be determined

Work to be Done:

1. Inspect chlorination building, mechanical, electrical, and power supply equipment for structural integrity, isolation and crossover capability and security requirements.
2. Implement interim seismic upgrade before permanent station is constructed if deficiency is observed.
3. Early Completion Item.

Facility: Rock River Lime Plant

Description: Wooden structure with two bulk bins for quick lime with capacity of nine tons per hour. Constructed 1950 and 1992.

Hazard Event: Seismic hazard events:
Minimal. PGA less than 0.0 – 0.1 for all seismic events.
Fire events could threaten water quality and facility. There is a medium fire risk

Critical Function: Provide pH adjustment to protect pipeline from corrosion. This is the only corrosion prevention facility in the Hetch Hetchy system.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 9 tons per hour; 40 pounds lime per mg water	• To be determined
Structural	• Withstand a minimum of PGA 0.1-0.2 or meet Building Code requirements	• To be determined	• To be determined
Mechanical / Electrical	• Equipment and storage tanks to withstand PGA 0.1-0.2 or meet code requirements • Standby power	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect limefeed building, mechanical, electrical and power supply equipment for structural integrity, redundency and capacity requirements.
2. If deficient, implement improvements.
3. Early completion item.

Facility: Early Intake / Bypass

Description: Concrete arch dam, 262 feet long
2,000 feet of mostly unlined bypass tunnel

Hazard Event: Seismic Hazard:
Minimal (PGA's for all seismic events are less than 0.1)

Critical Function: Convey water from Kirkwood Powerhouse to Mountain Tunnel

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• To be determined	• To be determined
Structural	• Meet Division of Dam and Safety requirements	• Adequate	• None
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform dam safety inspection/evaluation per Division of Dam Safety requirements.
2. Perform tunnel inspection every 20 years.
3. Early completion item.

Facility: O'Shaughnessy Dam / Hetch Hetchy Reservoir

Description: 360,360 acre feet capacity, concrete gravity arch dam, 910 feet long, constructed in 1923, 1938

Hazard Event: Seismic hazards events:
Minimal. PGA less than 0.0 – 0.1 for all seismic events.
Storm events could cause water quality problems.

Critical Function: Major supply source to SFPUC water supply system.
The dam must survive to prevent loss of life and property.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 360,360 acre feet	• 360,360 acre feet	• None
Structural	• Conforming to Division of Dam Safety requirements	• Adequate	• None
Intake (same as Mechanical/ Electrical?)	• High quality water to be supplied to the system	• Only one discharge elevation is available	• No choice in water quality from HH Reservoir
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform dam safety inspection and monitoring per Division of Dam Safety requirements.
2. Evaluate water quality benefit for the construction of alternative intake/penstock at O'Shaughnessy Dam to allow best quality of water to be used.
3. If water quality benefits justify the construction of alternative intake,
    a. Complete intake design and environmental evaluation process.
    b. Construct alternative intake.
4. Early Completion Item.

Facility: Priest Reservoir / Dam (Page 31, 32) [1]

Description: 1,851 acre feet capacity, constructed in 1923, earth and rock dam, 1160 feet long.

Hazard Event: Worst seismic event:
Minimal (All seismic events have a PGA less than 0.0 – 0.1).
Water quality events caused by storms, swallows and slope protection.

Critical Function: Only facility linking Mountain Tunnel with Moccasin Powerhouse/Reservoir System

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 1,851 acre feet	• 1,851 acre feet	• None
Structural	• Conforming to Division of Dam Safety Requirements	• Adequate	• None
Water Quality	• High quality water to be delivered to the system	• Potential stormwater overflow to the reservoir during severe storm events	• Adequate protection from storm runoff is needed
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect and monitor dam in accordance with Division of Dam Safety requirements.
2. Evaluate stormwater bypass/diversion alternatives and implement most feasible alternative.
3. Early Completion Item.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Upper Moccasin Creek Dam/Pipeline and Moccasin Dam/Reservoir

Description: Upper Moccasin Creek Dam/Pipeline: concrete gravity dam; 321 foot crest length; constructed in 1936

Moccasin Dam/Reservoir: 531 acre feet capacity; earth and rock dam; 855 foot crest length; constructed in 1929

Hazard Event: Seismic hazards events:

Minimal. PGA less than 0.0 – 0.1 for all seismic events. (The facilities have been determined to be near the New Melones fault; this fault has been determined to be inactive, therefore there is no risk)

Flood events will cause water quality problems and interruptions in power

Critical Function: These reservoirs primarily associated with power generation and peaking regulate the water discharged from the associated Moccasion Powerhouse to the Foothill Tunnel.

Delivery Capability Assessment:

CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 531 acre feet total	• To be determined
Structural	• Conforming to Division of Dam Safety requirements	• To be determined	• To be determined
Mechanical/Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Inspect structural and mechanical integrity of outlet structure and appurtenant equipment.
3. If deficient, repair and implement improvements.
4. Early completion item.

Facility:	Lake Eleanor Dam/Reservoir
Description:	27,100 acre feet capacity, concrete buttressed arch dam, 1,260 feet long, constructed in 1918
Hazard Event:	Seismic hazards events: Minimal. PGA less than 0.0 – 0.1 for all seismic events.
Critical Function:	Supplement water storage to Lake Lloyd for power production and alternative water supply.

Delivery Capability Assessment:

CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 27,100 acre feet	• To be determined
Structural	• Conforming to Division of Dam Safety requirements	• To be determined	• To be determined
Mechanical/Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Inspect structural and mechanical integrity of outlet structure and appurtenant equipment.
3. If deficient, repair and implement improvements.
4. Early completion item.

Facility: Cherry Dam and Reservoir

Description: 268,800 acre feet capacity; earth rock fill dam; 2,600 feet long; constructed in 1955

Hazard Event: Seismic hazards events:
Minimal. PGA less than 0.0 – 0.1 for all seismic events.

Critical Function: Provide water storage to generate power and augment Hetch Hetchy water reservoir supply.

Delivery Capability Assessment:

CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 268,800 acre feet	• To be determined
Structural	• Conforming to Division of Dam Safety requirements	• To be determined	• To be determined
Mechanical/Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Inspect structural and mechanical integrity of outlet structure and appurtenant equipment.
3. If deficient, repair and implement improvements.
4. Early completion item.

Facility: San Joaquin Pipeline Nos. 1, 2, & 3 / Crossings

Description: SJPL No. 1: 56 to 72-inch steel, capacity 70 mgd, 250,348 feet (47.4 miles), constructed 1932

SJPL No. 2: 61-inch steel and reinforced concrete, capacity 80 mgd, constructed 1953

SJPL No. 3: 78-inch steel and prestressed concrete, capacity 150 mgd, constructed 1968

Hazard Event: Worst case hazard event:

Great Valley fault (6.7 magnitude), PGA 0.4-0.5 from Tesla Portal to San Joaquin River, PGA 0.1-0.3 from San Joaquin River to Oakdale Portal

Hazard event following which the facility must remain operable:

San Andreas Fault (7.9 magnitude), PGA 0.1-0.2 from Tesla Portal to east Modesto, PGA 0.0-0.1 from east Modesto to Oakdale Portal.

Critical Function: Only means to deliver water from Foothill Tunnel to Coast Range Tunnel

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 260 mgd	• No.1-70 mgd • No. 2-80 mgd • No. 3-150 mgd	• To be determined
Structural	• Withstand a minimum PGA of 0.4-0.5	• No. 1 is at the end of useful life, • No. 2 is also 46 years old. • Sections of No. 3 (33, 078 feet) is PCCP	• To be determined
Mechanical/ Electrical	• Valving stations to provide switchover and isolation in case of damage • Flexible joints to allow movement	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect pipeline interior and exterior, pipe supports, portals, flexible joints, valving stations, river crossings including Roselle Crossing, and metering stations for structural, mechanical, electrical and security adequacy.
2. Perform seismic upgrade evaluation, risk analysis and cost benefit analysis if upgrade is needed.
3. Evaluate upgrade options, include replacement, strengthen pipe joints, additional valve stations, and increase capacity if required.
4. Early Completion Item.

Facility: Holm Power House/Penstock (Page 25) [1]

Description: Constructed 1960
Turbines: 2 turbines, vertical shaft-type, 6-jet impulse nozzles
Generators: 2 generators, 75,000kVA, 95% power factor

Hazard Event: Seismic Hazard:
Minimal (PGA's for all seismic events are less than 0.1)

Critical Function: Key power facility to generate power revenue for SFPUC.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• To be determined	• To be determined
Structural	• Meet Building Code requirements	• Geotechnical condition of penstock may be problematic	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• Automated surveillance • Fire suppression system installed	• Staffed part time • To be determined	• To be determined • Adequate

Work to be Done:

1. Perform routine inspection and maintenance on building structural, mechanical and electrical equipment for age, wear-and-tear.
2. Repair or replacement of inferior equipment or parts.
3. Early Completion Item.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Kirkwood Power House/Penstock (Page 25) [1]

Description: Constructed 1967
Turbines: 3 turbine generators, vertical shaft-type, 6-jet impulse nozzles
37,500/43, 125kVA, 90% power factor
37,500/43, 125kVA, 90% power factor
40.58 MVA, 90% power factor

Hazard Event: Seismic Hazard:
Minimal (PGA's for all seismic events are less than 0.1)

Critical Function: Key power facility to generate power revenue for SFPUC.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• To be determined	• To be determined
Structural	• Meet Building Code requirements	• Geotechnical condition of Penstock may be problematic	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• Automated surveillance • Fire suppression system installed	• To be determined • Staffed part time	• To be determined • Adequate

Work to be Done:

1. Perform routine inspection and maintenance on building structural, mechanical and electrical equipment for age, wear-and-tear.
2. Repair or replacement of inferior equipment or parts.
3. Review geotechnical condition of Penstock.
4. Evaluate improvement options and implement improvements.
5. Early Completion Item.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Moccasin Powerhouse/Penstock (Page 35, 37)[1]

Description: Constructed 1969
540 million KWH / year average, reinforced concrete plant and control building

Hazard Event: Seismic Hazard:
Minimal (PGA caused by all seismic events are less than 0.1)

Critical Function: Main power generation facility, power revenue generator

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• N/A	• 540 M-KWH/YR	• None
Structural	• Meet Building Code requirements	• Adequate	• None
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• Automated surveillance • Fire suppression system	• Staffed • To be determined	• Adequate • To be determined

Work to be Done:

1. Inspect building structural, mechanical and electrical equipment for age, wear-and-tear.
2. Repair and/or replace if inferior components are observed.
3. Early Completion Item.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Canyon Power Tunnel (Page 23) [1]

Description:
2,230 ft of 9 ft steel pipe
50,038 ft of unlined horseshoe tunnel
2,784 ft of lined horseshoe tunnel

Hazard Event: Seismic Hazard:
Minimal (PGA for all seismic events are less than 0.1)

Critical Function: Convey water from Hetch Hetchy reservoir to SFPUC water system without water quality deterioration, particularly when the Sunol Valley Water Treatment Plant or the Harry Tracy Water Treatment Plant systems are out of service.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 700 mgd	• 700 mgd	• None
Structural	• Withstand design pressure	• Adequate	• None
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Repair if damage is observed.
3. Remove rock from rock trap every 20 years.
4. Evaluate the adequacy of security.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Coast Range Tunnel (Page 48) [1]

Description: 10 feet 6 inches concrete lined 151,213.44 feet (28.64 miles)
5 shafts

Hazard Event: Worst case seismic event:
Great Valley Fault (6.8 magnitude, PGA 0.4-0.5)
Seismic event following which the facility must remain operable:
San Andreas Fault (7.9 magnitude, PGA 0.1-0.2)

Critical Function: Transports water from San Joaquin Pipelines to Alameda Siphons, particularly following a San Andreas event, Hetch Hetchy supply must be transported to the customers.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• To be determined	• To be determined
Structural	• Withstand PGA 0.4–0.5 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 10 years.
2. Repair, clean, reline tunnel as necessary.
3. Perform risk analysis and evaluate structural integrity of existing tunnel, including fault crossing studies, improvement options, and cost-benefit analysis.
4. Early Completion Item.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Foothill Tunnel / Red Mountain Bar Siphon / Oakdale Portal (Page 39-41) [1]

Description: Total length 83,705 feet (15.85 miles), 8 miles concrete-lined.
Capacity: 620 second feet

Hazard Event: Seismic Hazard:
Minimal (PGA's for all seismic events are less than 0.1)

Critical Function: Convey water from Moccasin to San Joaquin Pipelines

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 620 second feet.	• 620 second feet.	• None
Structural	• Withstand design pressures	• Adequate	• None
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Clean, repair and/or reline if damage to tunnel, siphon and portals is observed.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Mountain Tunnel (Page 33, 34) [1]

Description: 64,499 feet (11.65 miles) lined, 38,156 feet (7.23 miles) unlined
Capacity: 620 second feet

Hazard Event: Seismic Hazard:
Minimal (PGA's for all seismic events are less than 0.1)

Critical Function: Only conveyance system from Early Intake to Priest Reservoir, a regulating reservoir to Moccasin Powerhouse

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 620 second feet	• 620 second feet	• None
Structural	• Withstand design conditions	• Adequate	• None
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Repair if damage is observed.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Priest Outlet and Moccasin Power Tunnel

Description: From the Priest Regulating Reservoir to the Moccasin Reservoir; 5,370 feet long; 770 mgd capacity.

Hazard Event: Seismic hazard event:

Minimal. PGA less than 0.0-0.1 for all seismic events.
(The facility has been determined to be near the New Melones fault; this fault has been determined to be inactive, therefore there is no risk)

Critical Function: Convey water from Priest Reservoir to Moccasin Powerhouse and the Water Supply System.

Delivery Capability Assessment:

CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 770 mgd	• To be determined
Structural	• Conforming to Division of Dam Safety requirements	• To be determined	• To be determined
Mechanical/Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Perform tunnel inspection every 20 years.
2. Inspect structural and mechanical integrity of outlet structure and appurtenant equipment.
3. If deficient, repair and implement improvements.
4. Early completion item.

Facility: Cherry Valve House

Description: Reinforced concrete structure containing Cherry Power Tunnel, shut-off valve, two emergency release valves with guard valves; constructed in 1967

Hazard Event: Seismic hazard events:
Minimal. PGA less than 0.0 – 0.1 for all seismic events.

Critical Function: Allows maintenance in Cherry Power Tunnel and provides emergency water supply and dam safety function by allowing release of water into Cherry River

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• To be determined	• To be determined
Structural	• To be determined	• To be determined	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect structural, mechanical, electrical equipment for structural integrity reliability and security conditions.
2. If deficient, estimate costs of improvements.
3. Implement improvements, and Early Completion Item.

Facility: Calaveras Dam / Reservoir (Page 9, 12) [1]

Description: 31 billion gallons (10.23 acre feet) capacity; 33 mgd yield; earth-filled dam; constructed in 1925.

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.2-0.3)
Hayward Fault (7.1 magnitude, PGA 0.5 -0.6)
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Great Valley Fault (6.7 magnitude, PGA 0.3-0.4)

Critical Function: The dam must survive to prevent loss of life and property downstream Store water to supplement the Hetch Hetchy system.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• N/A	• N/A	• N/A
Structural	• Dam to withstand PGA 0.6-0.7 to prevent loss of life and property • Outlet tower to withstand Great Valley event PGA 0.3-0.4 or lower to allow minor damage	• To be determined • To be determined	• To be determined • To be determined
Mechanical/ Electrical	• Valves in operating condition	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect dam per Division of Dam Safety requirements.
2. Exercise valves regularly.
3. Evaluate structural, mechanical, electrical integrity of dam, outlet tower, shaft, inlet and appurtenances to withstand PGA 0.6-0.7 or lower to allow minor damages.
4. If deficient:
    - Evaluate improvement options or change operational criteria

---

[1] SFWD and HHWP Data Book, 1994 revision

- Estimate cost of improvements
- Design improvements
- Construct improvements

5. Early Completion Item.

Facility: Crystal Springs Dam / Reservoir (Page 17) [1]

Description: 41.6 billion gallons capacity, (13.73 acre feet) 5.8 mgd yield, 1877, 1887-1890 construction.

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Dam must survive to prevent life and property loss of downstream communities. Crystal Springs Reservoir stores raw water to Harry Tracy Water Treatment Plant via Crystal Springs Pump Station. Crystal Springs Reservoir will be the only supply source under Calaveras or Hayward Fault events when Hetch Hetchy and East Bay sources are lost.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• N/A	• N/A	• N/A
Structural	• Dam and tunnel to withstand PGA 0.5-0.6 • 1 shaft to survive PGA 0.5-0.6 or allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Valves in operating condition	• Valves in operating condition	• None
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect dams per Division of Dam Safety requirements.
2. Evaluate structural, mechanical, electrical integrity of dam, outlet tower, shaft, inlet and appurtenances to withstand PGA 0.5-0.6 or lower and allow minor damages.

---

[1] SFWD and HHWP Data Book, 1994 revision

3. Exercise valves regularly.
4. If deficient:
    - Evaluate improvement options or change operational criteria.
    - Estimate cost of design and construction of improvements.
    - Design improvements.
    - Construct improvements
5. Early Completion Item.

Facility:	San Andreas Dam / Reservoir (Page 18) [1]
Description:	6.19 billion gallons capacity, yield 6.6 mgd including Pilarcitos Constructed in 1870, raised 1875.
Hazard Event:	Worst case seismic event: Calaveras Fault (6.8 magnitude, PGA 0.5-0.6) Seismic event following which this facility must be operable: San Andreas Fault (7.9 magnitude, PGA 0.5-0.6) Hayward Fault (7.1 magnitude, PGA 0.2 -0.3) Calaveras Fault (6.8 magnitude, PGA 0.1-0.2) Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)
Critical Functions:	San Andreas Dam must survive to avoid downstream loss of life and property. Store and supply raw water to Harry Tracy Water Treatment Plant.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 6.2 billion gallons	• 6.2 billion gallons	• None
Structural	• Dam to survive PGA 0.5-0.6 • 1 shaft to survive PGA 0.5-0.6 or lower, allow minor damages, but still operable	• To be determined	• To be determined
Mechanical/ Electrical	• Valves in operating condition	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Inspect dams per Division of Dam Safety requirements.
2. Evaluate structural integrity of shaft to withstand PGA 0.5-0.6 or lower and allow minor damages.
3. Exercise valves regularly.
4. If deficient:
   - Evaluate improvement options or change operational criteria.
   - Estimate cost of design and construction of improvements.
   - Design improvements.
   - Construct improvements
5. Early Completion Item

Facility: Turner Dam / San Antonio Reservoir (Page 13) [1]

Description: 16 billion gallons capacity, yield 4.7 mgd, constructed in 1965.

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.2-0.3)
Hayward Fault (7.1 magnitude, PGA 0.5 -0.6)
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Great Valley Fault (6.7 magnitude, PGA 0.3-0.4)

Critical Function: Provide storage of raw water for Sunol Valley Water Treatment Plant. The Dam must survive to prevent life and property loss downstream in seismic event

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• N/A	• N/A	• N/A
Structural	• Dam to withstand • PGA 0.6 – 0.7 • (Calaveras, Ms 6.8) • Outlet Tower to withstand PGA 0.6-0.7 or lower and allow minor damages.	• To be determined	• To be determined
Mechanical/ Electrical	• Valves in operating condition	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect dams per Division of Dam Safety requirements.
2. Evaluate structural integrity of shaft to withstand PGA 0.6-0.7 or lower and allow minor damages.
3. Exercise valves regularly.

---

[1] SFWD and HHWP Data Book, 1994 revision

4. If deficient:
   - Evaluate improvement options or change operational criteria.
   - Estimate cost of design and construction of improvements.
   - Design improvements.
   - Construct improvements
5. Early completion item

Facility: Pilarcitos Dam/Reservoir/Aqueduct

Description: Dam/Reservoir: 3,100 acre feet capacity; earth dam; 520 feet long; constructed in 1866, 1874.
Aqueduct: 40 mgd capacity; 2.66 miles; constructed between 1868 and 1941.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude) PGA 0.5 – 0.6
Landslides could threaten facilities
Flood events could cause water quality problems.

Critical Function: Dam and associated aqueduct provide supplemental water supply for San Andreas Reservoir and is the primary source for the Coastside Community Water District (Half Moon Bay). The Dam must survive to prevent life and property loss downstream.

Delivery Capability Assessment:

CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 3,100 acre feet	• To be determined
Structural	• Dam – Conforming to Division of Dam Safety requirements • Aqueduct	• To be determined • To be determined	• To be determined • To be determined
Mechanical/Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect Dam per Division of Dam Safety Requirements.
2. Evaluate structural integrity of Aqueduct and appurtenant structures.
3. If deficient, evaluate improvement options or change operating criteria.
4. Implement improvements, if feasible.
5. Early completion item.

Facility: Alameda Siphons (Page 49) [1]

Description:

Siphon	Constructed	Capacity, mgd	Diameter, inch	Pipe Material
No. 1	1934	67	69	Steel
No. 2	1953	134	91	Steel 7/16" plate
No. 3	1967	152	96	PCCP

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.2-0.3)
Great Valley Fault (6.7 magnitude, PGA 0.1-0.2)

Critical Function: Major conveyance facility to transport water from Hetch Hetchy and the East Bay to CDD and Bay Area Water Users Association (BAWUA) customers.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 67 mgd (No. 1) • 134 mgd (No. 2) • 152 mgd (No. 3)	• Adequate • Adequate • Adequate	• None • None • None
Structural	• To withstand PGA 0.6-0.7 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow movement • Valving to allow cross-over and isolation	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Conduct site specific geotechnical, structural and mechanical inspections.
2. Conduct a fault crossing study and evaluate the structural integrity of each pipe in withstanding PGA 0.6–0.7 or lower and allow minor damages.
3. Evaluate additional valving requirements for crossover and isolation.
4. If deficient, identify improvements including replacements, strengthen, construct redundant pipe(s) along alternative alignments including redundant supply for Town of Sunol, improve repair ability, or other options.
5. Estimate cost of improvements, engineering and construction and analyze cost-benefit.
6. The evaluation phase of this work, including a fault crossing study can be an Early Completion Item. The priority of this project needs to be assessed in Phase 3 study and implemented accordingly.
7. If a redundant Irvington Tunnel is a viable option to increase system reliability, alternative bypass siphons need to be constructed to link the Coast Range Tunnel with the Irvington Tunnel No. 2.

Facility: Bay Division Pipeline No. 1 and No. 2 between Irvington Portal and Newark Valve Lot (Page 50-53) [1]

Description:

BDPL No. 1: 57 inch reinforced concrete 6,821 feet (1.29 miles), constructed in 1933.
60 inch riveted steel 30,807 feet (5.90 miles), constructed in 1925.

BDPL No. 2: 62 inch reinforced concrete 17,475 feet (3.31 miles), constructed in 1935.
66 inch wrought steel 20,147 feet (3.82 miles), constructed in 1935.

Hazard Event:

Worst case seismic event:
  Hayward Fault (7.1 magnitude, PGA 0.4-0.7)
Seismic event following which this facility must be operable:
  San Andreas Fault (7.9 magnitude, PGA 0.2-0.4)
  Hayward Fault (7.1 magnitude, PGA 0.4 -0.7)
  Calaveras Fault (6.8 magnitude, PGA 0.3-0.6)
  Great Valley Fault (6.7 magnitude, PGA 0.1-0.2)

Critical Functions: BDPL No. 1 and No. 2 are the major supply lines for Hayward and Alameda County Water District.

---

[1] SFWD and HHWP Data Book, 1994 revision

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 40 mgd • Adequate pressure	• 46 mgd (BDPL No. 1), 59 mgd (BDPL No.2) • pressure unknown when backed from HTWTP	• Following a Hayward or Calaveras event, Water to this facility will be backfed from HTWTP. Pressure may not be adequate
Structural	• Withstand PGA 0.4-0.7	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow crossover, valves in operating condition	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate and analyze site specific geotechnical, structural and mechanical conditions. Analyze hydraulics and determine amount of water to be delivered to Hayward and Alameda County Water District customers with and without pressurization of Pulgas Tunnel.
2. Evaluate improvement options to withstand PGA 0.6 – 0.7 or allow minor damages. Conduct fault crossing study.
3. Estimate cost of design and construction of improvements.
4. The evaluation of BDPL No. 1, 2, 3 & 4 should be combined as one system.
5. The seismic evaluation and the backflow hydraulic study can be Early Completion Items. The implementation of most viable improvement alternative, its priority should be in the Phase 3, and implemented accordingly.

Facility: Bay Division Pipeline No. 1 and No. 2 west of Ravenswood Valve Lot Lot (Page 50-53) [1]

Description: BDPL No. 1: Ravenswood to Pulgas Portal, 60 inch riveted steel 47,857 feet (9.07 miles), constructed in 1925.

BDPL No. 2: Redwood City Pulgas Portal, 62 inch wrought steel 8, 194 feet (1.55 miles) 66 inch steel 21,353 feet (7.98 miles). constructed in 1935.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.9)
Seismic event following which this facility must be operable:
Hayward Fault (7.1 magnitude, PGA 0.1 -0.4)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.3)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Supply water to customers in Menlo Park, East Palo Alto and Palo Alto.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 46 mgd (BDPL No. 1) • 59 mgd (BDPL No. 2)	• 46 mgd (BDPL No. 1) • 59 mgd (BDPL No. 2)	• Adequate • Adequate
Structural	• Withstand PGA 0.5-0.9 or allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow crossover, valves in operating condition	• To be determined • To be determined	• Additional valving for BDPL No. 2 at Ravenswood valve lot. • Additional connection for Palo Alto PL to BDPL No. 1 and No. 2 downstream from Redwood City valve lot.
Security	• To be determined	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Evaluate site specific geotechnical, particularly the Edgewood Road alignment and Ravenswood area, structural and mechanical conditions.
2. Evaluate improvement options to provide additional valving and connections, strengthen existing pipes to withstand the worse case scenario or allow minor damages, and/or replace BDPL No. 1 and No.2 and/or phase out No. 1 and No.2 and replace with BDPL No. 5 under the Bay, along existing alignment of BDPL No. 3 and No. 4 or other viable route.
3. Estimate cost of design and construction of improvement options. Perform risk analysis and system analysis including BDPL No. 3 and No. 4
4. The evaluation of feasible improvement alternatives and cost-benefit analysis can be an Early Completion Item, the priority of this project needs to be evaluated in Phase 3 and implement accordingly.

Facility: Bay Division Pipeline No. 3 and No. 4 (Page 54-57)[1]

Description: Constructed in 1965, 1967, and 1973.

BDPL No. 3:
72 inch concrete reinforced pipe 36,591 feet (6.94 miles)
72 inch steel 96,237 feet (10.24 miles)
78 inch reinforced concrete 43,184 feet (8.18 miles)
78 inch steel 1,904 feet (0.36 mile)
90 inch 917 feet (0.17 mile), constructed in 1952.

BDPL No. 4:
84 inch PCCP 39,156 feet (7.42 miles)
90 inch steel 88,781 feet (16.83 miles)
96 inch PCCP 42,156 feet (7.99 miles)
other pipe sizes 7,635 feet (1.45 miles)

Hazard Event: Worst case seismic event:
East end: Hayward Fault (7.1 magnitude, PGA 0.6 -0.7)
West end: San Andreas Fault (7.9 magnitude, PGA 0.8-0.9)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.9-0.2 from Pulgas to Irvington)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.7 from Pulgas to Irvington)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.6 from Pulgas to Irvington)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.2 from Pulgas to Irvington)

Critical Functions: Transport water from Irvington Tunnel to the customers in South Bay an is the major facility to transport water to North of Pulgas and City of San Francisco.

---

[1] SFWD and HHWP Data Book, 1994 revision

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Normal operation: 80 mgd (BDPL No. 3) 120 mgd (BDPL No. 4) • Back feed from HTWTP after Hayward & Calaveras event, 60 mgd • East section 240 mgd and west section 200 mgd when BDPL No. 1 and No. 2 are lost	• 80 mgd (BDPL No. 3) 120 mgd (BDPL No. 4) • 80 mgd • To be determined	• Adequate • Adequate • East section may be deficient
Structural	• Withstand PGA 0.9-0.7 from Pulgas to Irvington or allow minor damage	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow crossover, valves in operating condition	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, particularly the alignment along Edgewood Road and the Ravenswood area, structural and mechanical conditions.
2. Evaluate improvement options to withstand San Andreas and Hayward events or allow minor damages. Improvement options should evaluate the BDPL Nos. 1, 2, 3 and 4 as one subsystem and include strengthen, replacement, enlargement, addition of No. 5, improve/replace BDPL No. 1 and 2, and improve repair ability.
3. The evaluation of feasible improvement alternatives, estimate of design and construction costs, and cost-benefit analysis should be combined with BDPL No. 1 and No.2 and can be an Early Completion Item. The priority of this project may be assessed in Phase 3 study. Feasible improvement should be implemented in accordance with the result of Phase 3 study.

Facility: Crystal Springs Bypass Pipelines (Page 69) [1]

Description: CSBP No. 1: 96 inch Prestressed concrete cylinder pipe 3,879 feet (0.74 miles)

97.5 inch steel 508 feet (0.1 mile), constructed in 1970

CSBP No.2: 84 inch, being constructed

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)

Critical Function: Supply water to customers north of Pulgas
When Crystal Springs Pump Station – Crystal Springs-San Andreas Pipeline – San Andreas Reservoir – Harry Tracy Water Treatment Plant system is not operable, Crystal Springs Bypass Pipeline/Tunnel is the only transmission system to transport water from Pulgas to north peninsula and CDD customers.

---

[1] SFWD and HHWP Data Book, 1994 revision

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Normal operation, 215 mgd • Backflow from HTWTP 120 MGD (Hayward or Calaveras events) • San Andreas event 160 mgd	• 215 mgd	• Adequate
Structural	• Withstand PGA 0.5-0.6 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow crossover, valves in operating condition	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, structural and mechanical conditions.
2. If deficient, identify improvement options including:
   - Strengthening to withstand PGA 0.5-0.6 or allow minor damages.
   - Construct Pulgas/Crystal Spring tunnels bypass line along Southern Pacific Right of Way, along Alameda de las Pulgas or other alignments. This evaluation should combine with Crystal Spring Bypass Tunnel and Pulgas Tunnel as one system.
   - Improve repair capability.
3. Estimate costs of improvement options (cost of engineering and construction) and perform cost-benefit analysis.
4. The study can be an Early Completion Item. The priority should be assessed in the Phase 3 study and recommended project be implemented in accordance with Phase 3 study results.

Facility: Crystal Springs Pipeline No. 1, No. 2, No. 3, and No. 3 extension (Page 71-73) [1]

Description:

CSPL No. 1:	under construction
CSPL No. 2:	capacity 52 mgd, 60 inch welded steel, 4.5 miles, 54 inch W.I. riveted pipe, 3.2 miles, 60 inch welded steel, 10.5 miles, constructed in 1937.
CSPL No. 3:	capacity 60 mgd, 60 inch PCCP 3.5 miles, constructed 1971.
CSPL No. 3x: (Extension)	capacity 60 mgd, 60 inch PCCP, 2.1 miles, 60 inch steel, 0.3 miles, constructed 1987

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Functions: Supply water to from Pulgas Tunnel to northern peninsula and San Francisco customers.
Provide raw water from Crystal Springs Reservoir if necessary. The only pipe feeds University Mound system.

---

[1] SFWD and HHWP Data Book, 1994 revision

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 52 mgd	• 52 mgd	• None
Structural	• Withstand PGA 0.6-0.7 or allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow crossover, valves in operating condition	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, structural and mechanical conditions.
2. Evaluate record drawings and construction specifications.
3. If deficient, identify improvement options including:
    - Strengthen or replacement of pipe to withstand PGA 0.6-0.7 or allow minor damages
    - Site specific geotechnical evaluation including liquifaction study along pipeline alignment
    - Additional valves and flexible joints
    - Improve repair capability
4. Estimate cost of design and construction.
5. The seismic upgrade study can be an Early Completion Item. The priority of this project needs to be part of the Phase 3 study. Design and construction of major improvements should be implemented in accordance with Phase 3 recommendations.

Facility: Crystal Springs-San Andreas Pipeline (Page 68) [1]

Description: 61 inch diameter, 22337 feet cement-lined coal tar coated & wrapped, steel, 1898 to 1932, 1968 construction

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Transfer water from Crystal Springs Reservoir to San Andreas Reservoir which feeds Harry Tracy Water Treatment Plant. When Hetch Hetchy and Sunol Valley Water Treatment Plant water supply is lost due to the Hayward or Calaveras Fault events, this is the only supply.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 144 mgd to meet current HTWTP treatment capacity	• 74 mgd	• 70 mgd prolonged operation of this pipeline will not meet HFWTP demands.
Structural	• Withstand PGA 0.6-0.7 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow movement • Adequate valving for isolation	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be done:

1. Inspect pipeline, tunnel and siphon.
2. Evaluate record drawings and construction specifications.
3. Evaluate site-specific geotechnical structural and mechanical conditions.
4. If deficient, evaluate improvement options, include:
    - Redundant pipe (alignment study).
    - Strengthening to PGA 0.6-0.7 or lower and allow minor damages.
    - Addition of flexible, seismic-resistant joints.
    - Improve repair capability.
5. Estimate cost of improvements, engineering and construction, analyze cost-benefit.
6. This pipeline shall also be evaluated as part of the Crystal Springs Reservoir – Crystal Springs Pump Station – Crystal Spring-San Andreas Pipeline – San Andreas Reservoir – Harry Tracy Water Treatment Plant system. The priority of improvements to this system should be evaluated in the Phase 3 study and improvements to be implemented in accordance with Phase 3 study results.

Facility: Palo Alto Pipeline (Page 63) [1]

Description: 36 inch steel 26,549 feet (5.03 miles), constructed in 1938.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: This facility is the only pipeline to supply water to customers in much of the Palo Alto Area.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 28 mgd	• 28 mgd	• Adequate
Structural	• Withstand PGA 0.6-0.7 or allow minor damages	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow common crossover. Valves should be in operating condition • Redundant connections to BDPL's	• To be determined • To be determined • No redundant connections to BDPL's 1-2 and 3-4	• To be determined • To be determined • Move connection to BDPL 1-2 to westside of Redwood City Valve Lot. Need redundancy in supply line
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, structural and mechanical conditions.
2. Evaluate improvement options including:
   - Connect to BDPL No. 1 and No. 2 to the West of Redwood City Valve lot.
   - Extend PAPL South to connect with BDPL No. 3 and No. 4 (Page Mill Road, Palo Alto or other alignment) to provide redundancy.
   - Strengthen pipe to withstand PGA 0.6 – 0.7 or lower and allow minor damages, or replace pipe.
3. Estimate cost of improvements and analyze cost/benefit.
   - Improve repair capability
4. Early Completion Item.

Facility: San Andreas Pipeline No. 1, No. 2, No. 3 (Page 79-81) [1]

Description:

SAPL No. 1: San Andreas to Baden 21.5 mgd capacity, Baden to Merced Manor 14 mgd capacity, size varies from 44 inch to 24 inch, 12.45 miles, constructed between 1870 and 1939

SAPL No. 2: 54 inch. steel, 55,890 feet (10.6 miles), Lake Honda Tunnel Branch 6,745 feet, Sunset Reservoir Branch 8,860 feet, constructed in 1927-1928.

SAPL No. 3: 66 inch PCCP, 3.32 miles (North of Baden), 66 inch steel, 3.14 miles (South of Baden), constructed 1992-1993

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.7)
Seismic event following which this facility must be operable:
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: These pipelines supply water from Harry Tracy Water Treatment Plant to CDD high zones, Daly City and California Water Company. When Harry Tracy Water Treatment Plant – Crystal Springs Pump Station system is lost following a San Andreas event, water from Hetch Hetchy needs to be pumped at Baden to deliver water to Daly City, California Water Company, and CDD high zones. The SAPL No. 2 is the only pipeline to deliver water to Sunset Reservoir.

---

[1] SFWD and HHWP Data Book, 1994 revision

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 40 mgd minimum	• 51 mgd • 61 mgd (with Sunset Supply Pipeline)	• Capacity adequate • No redundancy to Sunset Reservoir
Structural	• Withstand PGA 0.5-0.7 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow crossover and isolation	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, structural and mechanical conditions.
2. Review record drawings and construction specifications.
3. If deficient, evaluate improvement options. Strengthen to withstand PGA 0.5-0.7 or lower and allow minor damages. Add flexible joints and additional valving. Improve repair capability. Extend San Andreas Pipeline No. 3 to Sunset Reservoir.
4. Estimate cost of improvements, engineering and construction.
5. The seismic improvement evaluation may be an Early Completion Item. Priority should be assessed in the Phase 3 analysis. Major improvements need to be implemented in accordance with Phase 3 recommendations.

Facility: Sunset Supply Pipeline (Page 78) [1]

Description: Capacity varies, 54 inch to 91 inch welded steel from Crystal Springs Reservoir to Sunset Reservoir, 19.75 miles, 54 inch to 72 inch welded steel from San Andreas Reservoir to Millbrae, 1.22 miles, constructed between 1948-1958.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)

Critical Function: Convey water from Crystal Springs source to north peninsula and San Francisco customers

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
• **Capacity**	• Varies by section and system operation	• Varies depending on system operation. Total Sunset Supply Pipeline and Crystal Springs Pipeline No. 1 and No. 2 is ~141mgd	• Adequate
• **Structural**	• Withstand PGA 0.6-0.7 or lower and allow minor damages	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

• **Mechanical/ Electrical**	• Flexible joints to allow ground movements • Isolation valves to allow crossover valves in operating condition	• To be determined • To be determined	• To be determined • To be determined
• **Security**	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, structural and mechanical conditions.
2. Evaluate record drawings and construction specifications.
3. Evaluate improvement options including strengthening the pipe to withstand PGA 0.6 – 0.7 for a San Andreas event or lower and allow minor damages.
4. Evaluate improvement costs and cost-benefit analysis.
5. The seismic improvement evaluation of this pipeline can be an Early Completion Item.
6. Priority of this project needs to be assessed in the Phase 3 study. Major improvements should be implemented in accordance with Phase 3 recommendations.

Facility:	Calaveras Pipeline
Description:	Calaveras Reservoir to Sunol Valley WTP and on to San Antonio Pump Station; 90 mgd capacity; placed in service in 1934

44 inch welded steel CML&C pipe (1992)		20,540 feet
66 inch welded steel CML&C pipe (1965, 1992)		9,819 feet
	5.75 miles,	30,359 feet

Hazard Event: Worst case seismic events:
Calaveras Fault (6.8 magnitude), PGA 0.6-0.7
Seismic events following which the facility must remain operable:
San Andreas Fault (7.9 magnitude), PGA 0.2-0.3
Great Valley Fault (6.7 magnitude, PGA 0.1-0.2)
Landslides could threaten facilities

Critical Functions: Transport raw water from the Calaveras Reservoir and the San Antonio Reservoir to Sunol WTP.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• To be determined	• 90 mgd	• To be determined
Structural	• Withstand PGA 0.6-0.7 or allow minor damage	• To be determined	• To be determined
Mechanical/Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Conduct site-specific geotechnical, structural, and mechanical inspections and record drawings and specifics.
2. Evaluate structural integrity of pipe to withstand PGA 0.6-0.7 or allow minor damage.
3. Evaluate landslide potential.
4. Evaluate additional valving requirement for isolation and flexible joints to allow movements.
5. Estimate cost of improvements, engineering, and construction.

6. The priority of this project needs to be evaluated in conjunction with SVWTP as it is an integral part of the SVWTP system.

Facility: Baden Pump Station (Page 98)[1]

Description: Capacity: 50 mgd - 3 pumps.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Baden Pump Station pumps water from Crystal Springs Pipeline No.2 and Sunset Supply Pipeline to San Andreas No.2 to deliver water to Daly City, California Water Company and CDD high zones. This will be the only facility to deliver water to CDD high zones in the event that the Crystal Springs Pump Station – Harry Tracy Water Treatment Plant system is lost following a San Andreas event.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 50 mgd	• 50 mgd	• None
Structural	• Pump station building to withstand PGA 0.6-0.7 or lower and allow minor damages but operable	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Mechanical/ Electrical	• Flexible couplings on pipes to allow horizontal movement • Valving to allow crossover, isolation and bypasses • Spare pump • Surge protection • Standby power	• To be determined • To be determined • No spare pump • No surge protection • To be determined	• To be determined • To be determined • Spare pump • Surge protection • To be determined
Security	• Surveillance to prevent vandalism • Fire suppression system	• To be determined • To be determined	• To be determined • To be determined

Work to be Done:

1. Perform site specific structural, geotechnical, mechanical, electrical and security evaluation of the pump station and all of the appurtenances of the Baden Pump Station.
2. Review record drawings and construction specifications.
3. Identify deficiencies and evaluate improvement options to strengthen the pump station to withstand PGA 0.6-0.7 or lower and allow minor damages.
4. Estimate cost of improvements, engineering and construction.
5. Early Completion Item.

Previous Reports:

[Note: to be added based on information received from Ann Tobin at SFPUC]

Facility: Crystal Spring Pump Station (Page 98) [1]

Description: 4 pumps with capacity of 74 mgd, 1949 and 1979 construction.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Functions: Pump Crystal Spring Reservoir water to San Andreas Reservoir for treatment at Harry Tracy Water Treatment Plant. After a Hayward or Calaveras Fault event, the Crystal Pump Station – Harry Tracy Water Treatment Plant systems will be the only source of supply as Hetch Hetchy water is no longer available. If necessary, Crystal Springs Pump Station supplies raw water to Crystal Springs Pipeline No. 2 and Sunset Supply Line.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 144 mgd	• 74 mgd	• 70 mgd to meet HTWTP demands
Structural	• Pump station building to withstand PGA 0.5-0.6 or allow minor damages but operable	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Mechanical/Electrical	• Flexible couplings on pipes to allow horizontal movement valving to allow crossover, isolation and bypasses • Spare pump • Standby power	• To be determined • To be determined • To be determined	• To be determined • To be determined • To be determined
Security	• Surveillance to prevent vandalism • Fire suppression system	• To be determined • To be determined	• To be determined • To be determined

Work to be Done:

1. Perform site specific structural, geotechnical, mechanical, electrical and security evaluation of the pump station and all of its appurtenances of the Crystal Springs Pump Station.
2. Review record drawings and construction specifications.
3. Identify deficiencies and evaluate improvement options to strengthen the pump station to withstand or allow minor damage at PGA 0/5-0.6 or lower.
4. Estimate cost of improvements, engineering and construction.
5. Early Completion Item.

Previous Reports:

[Note: to be added based on information received from Ann Tobin at SFPUC]

Facility: Pulgas Pump Station / Crystal Springs Balancing Reservoir (Page 93)[1]

Description: Capacity: 5 pumps @ 30 mgd each, covered reservoir, 60 mgd, 1975 construction.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Pump treated water to Crystal Springs Balancing Reservoir to meet daytime needs.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 150 mgd	• 150 mgd	• None
Structural	• Withstand PGA 0.5-0.6 or lower, meet Building Code requirements and allow minor damages	• To be determined	• To be determined
Mechanical	• Seismic resistant equipment / anchors and all appurtenances	• To be determined	• To be determined
Electrical	• Standby generator with fuel supply	• To be determined	• To be determined
Security	• Automated surveillance when unmanned • Fire suppression system	• To be determined • To be determined	• To be determined • To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Review record drawings and specifications.
2. Perform site specific geotechnical, structural, mechanical / electrical systems inspection. Evaluate pump station, reservoir and appurtenances.
3. If deficient, evaluate improvement options to strengthen the reservoir roof, support columns and pump station structure to withstand PGA 0.5-0.6 or lower.
4. Estimate cost of improvements, engineering and construction.
5. Early Completion Item

Previous Reports:

[Note: to be added based on information received from Ann Tobin at SFPUC]

Facility:	San Antonio Pump Station
Description:	Constructed in 1968; upgraded in 1992 3 pumps @ 30.5 mgd each, 3 @ 34.3 mgd each, and 4 @ 10 mgd each.
Hazard Event:	Worst case seismic event: Calaveras Fault (6.8 magnitude, PGA 0.6-0.7) Seismic event following which this facility must be operable: San Andreas Fault (7.9 magnitude, PGA 0.2-0.3)
Critical Function:	Pump San Antonio water to Sunol Valley Water Treatment Plant for normal operation, pump water from Hetch Hetchy to Sunol Valley Water Treatment Plant for treatment in case of San Andreas event of Mw 7.9

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 160 mgd	• 160 mgd	• Adequate
Structural	• Building and equipment anchors to withstand PGA 0.6-0.7 or meeting Building Code requirements	• To be determined	• To be determined
Mechanical / Electrical	• Flexible couplings on pipes to allow movement • Valving to allow cross – over • Standby power	• To be determined • To be determined • To be determined	• To be determined • To be determined • To be determined
Security	• Automated surveillance • Fire suppression system	• Staffed • To be determined	• Adequate • To be determined

Work to be Done:

1. Perform site specific structural, geotechnical, mechanical, electrical and security inspection
2. Review record drawings and construction specifications
3. Identify deficiencies and Improvements, including withstanding PGA 0.6-0.7 or lower , upgrade building to conform to building code
4. Estimate cost of improvements of engineering and construction
5. Implement improvements
6. Early Completion Item

Previous Reports:

[Note: to be added based on information received from Ann Tobin at SFPUC]

Facility Name: Customer Service Connections

Description: The connections where customers tap onto San Francisco's water supply mains

Hazard Event:

Suburban Customer	Number of SFPUC Connections	Connections to SFPUC Mains	Must Remain Operable Event	Event Magnitude	PGA, G
Alameda County Water District	7	• BDPL 1&2 • BDPL 3&4	H	7.1	0.6-0.7
Belmont County Water District	2	• BDPL 1&2 • Crystal Springs Bypass Tunnel	SA	7.9	0.6-0.7
City of Brisbane / Guadalupe Valley MID	6	• Crystal Springs #2	SA	7.9	0.6-0.7
City of Burlingame	6	• Crystal Springs #2 & #3 • Sunset Pipeline	SA	7.9	0.6-0.7
CalWater (Bear Gulch)	7	• BDPL 1&2 • BDPL 3&4 • Palo Alto Pipeline	SA	7.9	0.5-0.6
CalWater (San Carlos)	3	• Bay Crossing 1&2	SA	7.9	0.8-0.9
CalWater (San Mateo)	4	• Crystal Springs #2 • Sunset Pipeline	SA	7.9	0.6-0.7
CalWater (South San Francisco)	11	• Crystal Springs #2 • San Andreas 1,2& 3 • Sunset Pipeline	SA	7.9	0.6-0.7
Coastside County Water District	2 (Raw water only)	N/A	SA	7.9	0.5-0.6
Cordilleras Mutual Water Association	1	BDPL 3	SA	7.9	0.8-0.9

Suburban Customer	Number of SFPUC Connections	Connections to SFPUC Mains	Must Remain Operable Event	Event Magnitude	PGA, G
City of Daly City	7	• Crystal Springs #2 • San Andreas 1,2&3 • Sunset Pipeline	SA	7.9	0.6-0.7
East Palo Alto Water District	3	• BDPL 1&2	SA	7.9	0.5-0.6
Estero Municipal Improvement District	1	• Crystal Springs #2	SA	7.9	0.6-0.7
City of Hayward	2	• BDPL 1&2	H	7.1	0.6-0.7
Town of Hillsborough	13	• Crystal Springs #2 • Sunset Pipeline	SA	7.9	0.8-0.9
Lawrence Livermore National Laboratory	1	• Coast Range Tunnel	GV	6.7	0.3-0.4
Los Trancos Water District	1	N/A	SA	7.9	0.8-0.9
City of Menlo Park	6	• BDPL 1&2 • BDPL 3&4 • Palo Alto Pipeline	SA	7.9	0.6-0.7
City of Millbrae	5	• Crystal Springs #2 • San Andreas 1,2&3 • Sunset Pipeline	SA	7.9	0.6-0.7
City of Milpitas	3	• BDPL 3&4	H	7.1	0.4-0.7
City of Mountain View	5	• BDPL 3&4	SA	7.9	0.5-0.6
NASA	3	• BDPL 3&4	SA	7.9	0.5-0.6
North Coast County Water District	1	• San Andreas 2&3	SA	7.9	0.5-0.6
City of Palo Alto	4	• BDPL 3&4 • Palo Alto Pipeline	SA	7.9	0.6-0.7
Purissima Hills Water District	2	• BDPL 3&4	SA	7.9	0.8-0.9

Suburban Customer	Number of SFPUC Connections	Connections to SFPUC Mains	Must Remain Operable Event	Event Magnitude	PGA, G
City of Redwood City	13	• Bay Crossing 1&2 • BDPL 1&2 • BDPL 3&4	SA	7.9	0.6-0.9
City of San Bruno	5	• Crystal Springs #2 • San Andreas 1,2& 3 • Sunset Pipeline	SA	7.9	0.6-0.7
San Francisco City Distribution Division	4	• Sunset Supply Line • Crystal Springs #2 • Baden-Merced • San Andreas #2	SA	7.9	Eastside 0.4-0.5 Westside 0.6-0.7
San Francisco County Jail	1	• San Andreas 2&3	SA	7.9	0.5-0.6
San Francisco International Airport	2	• Crystal Springs #2 • Sunset Pipeline	SA	7.9	0.5-0.6
City of San Jose (North San Jose Service Area)	1	• BDPL 3&4	SA	7.9	0.5-0.6
City of Santa Clara	2	• BDPL 3&4	SA	7.9	0.5-0.6
Skyline County Water District	1	• Bay Crossing 1&2	SA	7.9	0.6-0.7
Stanford University	3	• BDPL 3&4 • Palo Alto Pipeline	SA	7.9	0.5-0.6
City of Sunnyvale	6	• BDPL 3&4	SA	7.9	0.5-0.6
Westborough County Water District	1	• San Andreas 2&3	SA	7.9	0.6-0.7

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Varies, depending on each customers water supply system capability	• Varies, depending on size of each connection and pressure maintained in the system	• To be determined
Structural	• Withstand PGA caused by the dominating event	• To be determined	• To be determined
Mechanical	• Flexible joints to allow movements and isolation values	• To be determined	• To be determined
Redundancy	• Each customer needs to have a minimum of one connection to at least two supply mains.	• Most customers have multiple connections except the following customers have only one service connection each: • Cordilleras Mutual Water Company • Estero Municipal Improvement District • Lawrence Livermore National Laboratory • Los Trancos Water District • North Coast County Water District • San Francisco County Jail • City of San Jose (North S.J. Service Area) • Skyline County Water District • Westborough County Water	• Redundant service connections for customers listed

		District	
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect each service connection and evaluate structural mechanical integrity.
2. Review jointly with each customer regarding adequacy of capacity of each connection
3. For customers who have only one service connection, evaluate the feasibility of adding a connection to the second pipe or at a separate location.

Facility: Crystal Springs Bypass Tunnel (Page 91) [1]

Description: 114 inch concrete 17,150 feet (3.25 miles)
115 inch steel 500 feet (0.09 mile), constructed in 1969.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)

Critical Function: Convey water to customers north of Pulgas and CDD Low Zone from Hetch Hetchy and East Bay sources. This facility is the only link from Pulgas Tunnel to Crystal Springs pipelines.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Normal operation 215 mgd • Backflow from HTWTP 120 mgd following Hayward and Calaveras events • 160 mgd to meet peninsula and city demand following SA event	• 215 mgd	• To be determined
Structural	• Withstand PGA 0.5-0.6 or lower and allow minor damages.	• To be determined	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Inspect tunnel condition every 20 years.
2. Assess structural integrity of tunnel to withstand PGA 0.5-0.6 or allow minor damages. If deficient, evaluate improvement alternatives.
   - Parallel tunnel or bypass pipeline (alignment study) along Southern Pacific Right of Way, Alameda de las Pulgas or others
   - Strengthen / improve
   - Improve repair capability
3. Perform risk analysis and evaluate cost-benefit of improvement options. This evaluation needs to be combined with Pulgas Tunnel, and Crystal Springs Bypass Pipeline.
4. The seismic improvement study of this subsystem may be an Early Completion Item.
5. The priority of this project needs to be assessed in Phase 3, and improvements should be implemented in accordance with Phase 3 results.

Facility: Hillsborough Tunnel (Page 75) [1]

Description: 91 inch steel lined with concrete, 5,118 feet (0.97 mile), constructed in 1957.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)

Critical Function: Part of Sunset Supply Pipeline. Supply water to north Peninsula and San Francisco city customers, particularly after a San Andreas event when Crystal Springs Pump Station-Harry Tracy WTP system may be lost.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 141 mgd	• 141 mgd	• Adequate
Structural	• Withstand PGA 0.6-0.7 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect tunnel condition every 20 years.
2. Assess structural integrity of tunnel to withstand PGA 0.6-0.7 or lower and allow minor damages. If deficient, evaluate improvement alternatives.
    - Parallel tunnel or bypass pipeline (alignment study)
    - Strengthen / improve
    - Improve repair capability
3. Perform risk analysis and evaluate cost/benefit of improvement options.
4. Implement improvements if found feasible.
5. Early Completion Item.

---

[1] SFWD and HHWP Data Book, 1994 revision

Facility: Irvington Tunnel (Page 98) [1]

Description: 126 inch, 18,466 feet (3.5 miles), Capacity: 350 mgd

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.5 -0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Great Valley Fault (6.7 magnitude, PGA 0.1-0.2)

Critical Function: Irvington Portal must survive the worst case event to prevent loss of life and property. This tunnel supply water to Bay Divisions pipelines. After a San Andreas event, Hetch Hetchy and East Bay water have to be transported to South Bay, Peninsula and CDD customers via Irvington Tunnel.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 350 mgd	• 350 mgd	• None
Structural	• Withstand worst case PGA 0.6-0.7 or lower, allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect tunnel condition if not inspected for 10 years.
2. Confirm structural integrity of tunnel to withstand PGA 0.6-0.7. If deficient, evaluate improvement alternatives.
    - Parallel tunnel or bypass pipeline (alignment study)
    - Strengthen/improve tunnel
    - Improve repair capability

---

[1] SFWD and HHWP Data Book, 1994 revision

3. Perform risk analysis and evaluate cost-benefit of improvement options. This study needs to include Alameda Siphons as new alignment will impact both facilities.
4. The seismic improvement study including fault crossing studies for the tunnel is an Early Completion Item. The priority of this project needs to be assessed in Phase 3. Improvements should be implemented in accordance with Phase 3 recommendations.

Facility: Pulgas Tunnel (Page 58) [1]

Description: 123 inch concrete lined 9,016 feet (1.71 miles), 108 inch bottom width concrete lined outfall canal 963 feet (0.18 mile, constructed in 1926.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)

Critical Function: Normally convey water from Hetch Hetchy to Peninsula and CDD users following an San Andreas Fault event. This facility brings the Hetch Hetchy and East Bay supplies to the customers. Following a Hayward Fault event, backflow from Harry Tracy Water Treatment Plant to the Bay Division Pipeline is transported via Pulgas Tunnel.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 100 mgd (reverse flow) following Hayward Fault event • 140 mgd following San Andreas event	• To be determined	• None
Structural	• Withstand PGA 0.5-0.9 or lower and allow minor damages • Withstand backflow pressure from HTWTP	• To be determined • To be determined	• To be determined • To be determined
Mechanical/ Electrical	• Maintain acceptable pressure for East Bay customers when backflow from HTWTP	• To be determined	• Current spill elevation of 303' may need to be raised during backflow.
Security	• To be determined	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Inspect tunnel condition if not inspected for 20 years
2. Assess feasibility of pressurization of Pulgas Tunnel
3. Assess structural integrity of tunnel to withstand PGA 0.5-0.6 or lower and allow minor damages. If deficient, evaluate improvement alternatives
4. Parallel tunnel or bypass pipeline (alignment study)
5. Strengthen / improve
6. Improve repair capability
7. Perform risk analysis and evaluate cost benefit of improvement options. This study needs to be combined with the Crystal Springs Bypass Pipeline and Crystal Springs Bypass Tunnel evaluation as one subsystem. This seismic improvement study can be an Early Completion Item.
8. Priority of improving this subsystem should be conducted in Phase 3 analysis. Improvements should be implemented in accordance with Phase 3 recommendations.

Facility: Stanford Tunnel (Page 89) [1]

Description: 90 inch cement lined steel plate pipe 810 feet (0.15 mile), constructed in 1952.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.5-0.6)
Hayward Fault (7.1 magnitude, PGA 0.1 -0.2)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Link east sections of Bay Division Pipelines No. 3 and No. 4 to west sections

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 200 mgd	• 200 mgd	• Adequate
Structural	• Withstand PGA 0.5-0.6 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• To be determined	• To be determined	• To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Inspect tunnel condition every 20 years.
2. Assess structural integrity of tunnel to withstand PGA 0.5-0.6 or lower and allow minor damages. If deficient, evaluate improvement alternatives.
    - Parallel tunnel or bypass pipeline (alignment study)
    - Strengthen/improve
    - Improve repair capability

---

[1] SFWD and HHWP Data Book, 1994 revision

3. Perform risk analysis and evaluate cost-benefit of improvement options. This study needs to be combined with BDPL Nos. 1, 2, 3, and 4 as a system, as alternative improvements may provide redundancy for all these pipelines.
4. Seismic improvement study of the BDPL Nos. 1, 2, 3, and 4 subsystem can be an Early Completion Item. The priority of this subsystem as compared to other project can be analyzed in Phase 3. Improvements should be implemented in accordance with Phase 3 recommendations.

Facility Name: Water Supply & Treatment Division Valve Lots

Description: Various locations where valves are installed on pipelines to provide control over water flow

Hazard Event:

Valve Lot Name	Must Remain Operable Event	Event Magnitude	PGA, G
1. Capuchino	SA	7.9	0.5-0.6
2. San Pedro	SA	7.9	0.6-0.7
3. Baden	SA	7.9	0.5-0.6
4. Millbrae Yard	SA	7.9	0.6-0.7
5. El Camino Real & Bellevue (Burlingame)	SA	7.9	0.6-0.7
6. Bellevue & Pepper	SA	7.9	0.6-0.7
7. Crystal Springs & El Cerrito	SA	7.9	0.6-0.7
8. Pulgas	SA	7.9	0.5-0.6
9. Hillsborough	SA	7.9	0.6-0.7
10. Redwood City	SA	7.9	0.8-0.9
11. Ravenswood	SA	7.9	0.6-0.7
12. Dumbarton	H	7.1	0.4-0.5
13. Caisson	SA, H	7.9, 7.1	0.4-0.5
14. Edgewood Road	SA	7.9	0.8-0.9
15. Mountain View – Alviso	SA	7.9	0.6-0.7
16. Calaveras Blvd	C	7.1	0.6-0.7
17. Newark	H	7.1	0.4-0.5
18. Irvington Portal	H	7.1	0.6-0.7
19. Alameda West	SA	6.8	0.2-0.3
20. Alameda East	SA	6.8	0.2-0.3

Critical Function: Provide isolation and crossover capability for water supply from Hetch Hetchy, Sunol, and/or Harry Tracy Water Treatment Plant to each customer via major transmission pipelines.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Varies, depending on the operational strategy under specific hazard events. In general, required flow under a disaster scenario is lower than normal demands	• Adequate for normal flow	• None
Structural	• Need to withstand the PGA caused by the dominating event or allow minor damage	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow horizontal displacement and enough valving to allow isolation and crossover	• Mostly adequate, but each valve lot needs to be assessed separately	• To be determined
Security	• Unmanned facilities require automatic surveillance	• To be determined	• To be determined

Work to be Done:

1. Perform geotechnical, structural, mechanical and security inspection of each valve lot including:
    - Site-specific geotechnical information
    - Record drawings and construction specifications
    - Security
2. If deficient, evaluate improvement alternatives and estimate cost of improvement for each valve lot.
3. Prepare construction schedule for valve lot improvement program.
4. Implement improvements.
5. Early Completion Item.

Facility: Harry Tracy Water Treatment Plant (Page 107) [1]

Description: 180 mgd capacity; constructed in 1972, 1988, and 1990

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
Hayward Fault (7.1 magnitude, PGA 0.2 -0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, PGA 0.0-0.1)

Critical Function: Only source of supply to SFPUC customers if Hetch Hetchy and East Bay sources are lost.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 260 mgd	• 144 mgd	• 114 mgd
Structural	• Withstand PGA 0.6-0.7 or lower and allow minor damages	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints on pipes, and seismic proofing of mechanical equipment] • Emergency generator with 1 to 2 weeks fuel supply	• To be determined • 8 hours fuel supply	• To be determined • Fuel supply to be increased
Security	• Surveillance • Fire suppression system	• Staffed at all times • To be determined	• Adequate • To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Work to be Done:

1. Evaluate capacity requirements.
2. Perform site specific geotechnical / seismic evaluation.
3. Evaluate structural integrity: building, tanks, yard piping, storage reservoirs, equipment and chemical tank anchors.
4. Evaluate improvement options, perform risk analysis, and estimate cost of improvements for engineering, design and construction. This evaluation may be combined with Crystal Springs Pump Station, Crystal Springs Reservoir, Crystal Spring – San Andreas Pipeline, and San Andreas Reservoir and Harry Tracy Water Treatment Plant as a subsystem. The seismic improvement study of this subsystem is an Early Completion Item.
5. The priority of this subsystem needs to be evaluated in Phase 3 study. Improvements need to be implemented in accordance with Phase 3 recommendations.

Facility: Sunol Valley Water Treatment Plant (Page 106) [1]

Description: 80 mgd design capacity and 160 mgd maximum capacity; constructed in 1966, 1976.

Hazard Event: Worst case seismic event:
Calaveras Fault (6.8 magnitude, PGA 0.6-0.7)
Seismic event following which this facility must be operable:
San Andreas Fault (7.9 magnitude, PGA 0.2-0.3)
Great Valley Fault (6.7 magnitude, PGA 0.1-0.2)

Critical Function: One of the three sources of supply for SFPUC. If Hetch Hetchy source is lost Sunol Valley Water Treatment Plant must be operable. If Harry Tracy Water Treatment Plant is lost, Sunol Valley Water Treatment Plant must remain operable to supplement Harry Tracy Water Treatment Plant supply.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Existing 160 mgd • Additional capacity may be required in the valley	• 87 mgd if ≥ 10 NTU • 118 mgd if ≤ 10 NTU	• Being determined
Structural	• Structures to withstand PGA 0.6-0.7 or meet Building Code requirements • Chemical tanks anchoring need to withstand PGA 0.6-0.7 or lower and allow minor damages.	• To be determined • To be determined	• To be determined • To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Mechanical/ Electrical	• Flexible joints on pipes, and seismic resistant anchors • Emergency generator with 1 to 2 weeks fuel supply	• To be determined • To be determined	• To be determined • To be determined
Security	• Surveillance • Fire suppression system	• Staffed at all times • To be determined	• Adequate • To be determined

Work to be Done: (Capital Improvement in Progress)

1. Confirm capacity requirements with Sunol Valley Water Treatment Plant improvement project.
2. Perform site specific geotechnical / seismic evaluation and risk analysis.
3. Evaluate structural integrity: building, tanks, yard piping, storage reservoirs, equipment and chemical tank anchors.
4. Evaluate improvement options.
5. Estimate cost of improvements, engineering design and construction.
6. The seismic improvement evaluation is an Early Completion Item.

Facility: Covered Reservoirs, including Sunset, University Mound, Sutro, Summit, College Hill, Stanford Heights, and Merced Manor. (Page 87)[1]

Description: Storage reservoirs for San Francisco's water supply

RESERVOIR	TOTAL CAPACITY	TYPE	YEAR BUILT
Sunset	176.7 mg	Concrete, Two-basin	North (1938) South (1960)
University Mound	140.9 mg	Concrete, Two-basin	North (1927) South (1937)
Sutro	31.4 mg	Concrete, Two-basin	1952
Summit	14.0 mg	Concrete, Two-basin	1954
College Hill	13.5 mg	Asphalt sides and bottom, Tar and gravel roof	1870
Stanford Heights	12.9 mg	Concrete, Two-basin	1923
Merced Manor	9.5 mg	Concrete	1936

Hazard Event: Worst case seismic event:

San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)

Seismic events following which this facility must remain operable

San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2-0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, 0.0 – 0.1)

Critical Function: Supply potable water and fire protection water to city customers.

---

[1] SFWD and HHWP Data Book, 1994 revision

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Sunset 176.7 mg • University Mound 140.9 mg • Sutro 31.4 mg • Summit 14.0 mg • College Hill 13.5 mg • Stanford Heights 12.9 mg • Merced Manor 9.5mg	• Adequate	• None
Structural	Withstand PGA 0.6-0.7		
	• Sunset	• To be determined	• To be determined
	• Sutro	• To be determined	• To be determined
	• Summit	• To be determined	• To be determined
	• Stanford Heights	• To be determined	• To be determined
	• Merced Manor	• To be determined	• To be determined
	Withstand PGA 0.4-0.5		
	• University Mound	• To be determined	• To be determined
	• College Hill	• To be determined	• To be determined
Mechanical / Electrical	• Flexible connection to allow minor horizontal movement	• To be determined	• To be determined
	• Valving to allow switchover, isolation and bypasses	• To be determined	• To be determined
	• Individual line for inlet and outlet pipe to meet water demand, maintain chlorine residual and control formation of disinfection	• To be determined	• To be determined
	• Spare parts for hypochlorinators	• To be determined	• To be determined
	• Standby Power	• To be determined	• To be determined
Security	• Surveillance to prevent vandalism, foul play and break-ins	• To be determined	• To be determined
	• Fire suppression to protect public from fire loss	• To be determined	• To be determined

Work to be Done:

1. Review record drawings and construction specifications.
2. Conduct inspections including site specific geotechnical, structural, mechanical/electrical systems, and security conditions. This work needs to incorporate the findings of te seismic study of Reservoir Roofs and coordinate with CDD's Reservoir Improvement Project.
3. Estimate cost of improvements, engineering and construction.
4. Design improvements to withstand PGA as indicated above or allow minor damage.
5. Construct improvements.
6. Early completion item.

Facility: CDD Hydropneumatic Pump Stations

Description: These stations are used to boost the water supply system pressure for providing water to customers in the hilltop neighborhoods. The following is general information on the city hydropneumatic pump stations.

PUMP STATION	YEAR BUILT	# OF PUMPS	PUMP CAPACITY (MGD)
Crocker Amazon	1956 1961	2 1	0.6
Vista Francisco	1965	2	0.8
Palo Alto	1958	2	0.4
Forest Hill	1963	2	0.6
Lincoln Park	1947	2	0.4
Skyview – Aqua Vista	1962	2	0.6
Forest Knolls	1960	2	0.7

Hazard Event: Worst case seismic event following which the facility m.ust remain operable:

- San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)

Critical Function: Pump water against hydroneumatic tanks and maintain pressure in the system.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Crocker Amazon 0.6 mgd • Vista Francisco 0.8 mgd • Palo Alto 0.4 mgd • Forest Hill 0.6 mgd • Lincoln Park 0.4 mgd • Skyview–Aqua Vista 0.6 mgd • Forest Knolls 0.7 mgd	• Adequate	• None
Structural	Withstand PGA 0.6-0.7 or lower and allow damages • Crocker Amazon • Vista Francisco • Palo Alto • Forest Hill • Lincoln Park • Skyview – Aqua Vista • Forest Knolls	• To be determined • To be determined • To be determined • To be determined • To be determined • To be determined • To be determined	• To be determined
Mechanical / Electrical	• Flexible joint to allow horizontal movement • Isolation valves' to allow switchover • Spare pump to allow replacement • Pump anchor and hydroneumatic tank to withstand PGA 0.6-0.7 or lower and allow minor damages • Portable power generators	• To be determined • To be determined • To be determined • To be determined • To be determined	• To be determined
Security	• Automated Surveillance • Fire suppression system	• Unstaffed • To be determined	• To be determined • To be determined

Work to be Done:

1. Review record drawings and construction specifications.
2. Conduct site specific geotechnical, structural, mechanical and security inspection.
3. Identify deficiencies and improvement options to withstand PGA as indicated above.
4. Estimate cost of improvements, engineering and construction.

Facility: Crosstown Pipeline (Page 83) [1]

Description: 36 inch steel: 12,130 feet (2.30 miles); 44 inch steel 5,565 feet (1.05 miles), constructed in 1936.

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic events following which this facility must remain operable
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2-0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, 0.0 – 0.1)

Critical Function: The only pipeline to convey water from CDD high zone to low zone.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 40 mgd based on 50% City ADD	• 51 mgd from Alemany[2] • 30 mgd from San Andreas or Sunset to Upper Mound	• Adequate
Structural	• Withstand PGA 0.6-0.7	• To be determined	• To be determined
Mechanical/ Electrical	• Flexible joints to allow ground movements • Isolation valves to allow switchover	• To be determined • To be determined	• To be determined • To be determined
Security	• To be determined	• To be determined	• To be determined

Work to be Done:

1. Evaluate site specific geotechnical, structural and mechanical conditions.
2. Evaluate record drawings and construction specifications. If deficient, evaluate improvement options to withstand PGA 0.6 – 0.7 or lower and allow minor damages,

---

[1] SFWD and HHWP Data Book, 1994 revision
[2] Source: CDD Staff, June 30, 1999

constant redundant cross town pipeline/tunnel along alternative alignments, or a combination of above, and improve repair capability.

3. Estimate engineering of alternative improvements and perform cost/benefit analysis and construction costs.
4. Implement best alternative, design and construct.
5. Early completion item.

Facility: Alemany Pump Station

Description: 3 pumps with capacity of 41 mgd, constructed in 1942[1] .

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic events following which this facility must remain operable
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2-0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, 0.0 – 0.1)

Critical Function: Pump water from the low zone to the high zones. Following the San Andreas Fault event, Alemany Pump Station pumps water form University Mound Reservoir to the Sunset and College Hill reservoirs, if westside facilities and/or HTWTP system is lost.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 40 mgd based on 50% ADD	• 32 mgd with three pumps parallel[2]	• None
Structural	• For the pump station building to withstand PGA 0.6-0.7 or conform to Building Code	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision
[2] Source: CDD Staff, June 30, 1999

Mechanical / Electrical	• Flexible couplings on pipes to allow horizontal movement • Valving to allow switchover, isolation and bypasses • Spare pump and pump parts • Standby power and fuel supply	• To be determined • To be determined • To be determined • To be determined • To be determined	• To be determined • To be determined • To be determined • To be determined • To be determined
Security	• Surveillance to prevent vandalism • Fire suppression system	• To be determined • To be determined	• To be determined • To be determined

Work to be Done:

1. Perform site specific structural, geotechnical, mechanical, electrical and security evaluation of the existing conditions. Also evaluate adequacy of capacity and redundancy.
2. Review record drawings and construction specifications.
3. Identify deficiencies and evaluate improvement options to strengthen the pump station to withstand or allow minor damage at PGA 0.6-0.7. The capacity and redundancy deficiencies need to be improved in conjunction with the crosstown pipeline options.
4. Estimate cost of improvements, engineering and construction.
5. Early completion item.

Facility: Central Pump Station

Description: 2 pumps with capacity of 12.03 MGD, 1941 original construction and expanded in 1968.

Hazard Event: Worst case seismic event:

San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)

Seismic events following which this facility must remain operable

San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2-0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, 0.0 – 0.1)

Critical Function: Supply water to Stanford Heights System.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 12.03 mgd	• 12.03 mgd	• None
Structural	• For the pump station building to withstand PGA 0.6-0.7 or to conform to Building Code.	• To be determined	• To be determined
Mechanical / Electrical	• Flexible couplings on pipes to allow horizontal movement • Valving to allow switchover, isolation and bypasses • Spare pump and pump parts • Standby power	• To be determined • To be determined • To be determined • To be determined	• To be determined • To be determined • To be determined • To be determined
Security	• Surveillance to prevent vandalism • Fire suppression system	• To be determined • To be determined	• To be determined • To be determined

Work to be Done:

1. Perform site specific evaluation of structural, geotechnical, mechanical, electrical and security conditions. Evaluate adequacy of capacity and redundancy.
2. Review record drawings and construction specifications.
3. Identify deficiencies and evaluate improvement options to strengthen the pump station to withstand or allow minor damage at PGA 0.6-0.7.
4. Estimate cost of improvements, engineering and construction.
5. Early completion item. This work is to be coordinated with the Central Pump Station Upgrading Project.

Facility:	Lake Merced Pump Station (Page 83 and 97) [1]
Description:	8 pumps with capacity of 51 mgd, 1953 construction
Hazard Event:	Worst case seismic event: San Andreas Fault (7.9 magnitude, PGA 0.6-0.7) Seismic events following which this facility must remain operable San Andreas Fault (7.9 magnitude, PGA 0.6-0.7) Hayward Fault (7.1 magnitude, PGA 0.2-0.3) Calaveras Fault (6.8 magnitude, PGA 0.1-0.2) Great Valley Fault (6.7 magnitude, 0.0 – 0.1)
Critical Function:	Pump water to Sunset and Sutro System. Serves more than 60% of the population of San Francisco with potable water. Lake Merced Pump Station is also the operations center for City Distribution Division's 18 pump stations, 11 reservoirs and 8 storage tanks. Lake Merced Pump Station will serve as a backup facility to serve Surto after the Central Pump Station is upgraded.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• 33.77 mgd to Sunset • 16.66 mgd to Sutro	• 33.77 mgd to Sunset • 16.66 mgd to Sutro	• Adequate • Adequate
Structural	• For the pump station building to withstand PGA 0.6-0.7 or lower to conform to Building Code	• To be determined	• To be determined

---

[1] SFWD and HHWP Data Book, 1994 revision

Mechanical / Electrical	• Flexible connection for the pump station building to allow minor horizontal displacement	• To be determined	• To be determined
	• Valving to allow switchover, isolation and bypasses	• To be determined	• To be determined
	• Spare pump and pump parts	• To be determined	• To be determined
	• Spare parts for chlorine feeder	• To be determined	• To be determined
	• Standby power and fuel supply	• To be determined	• To be determined
Security	• Surveillance to prevent vandalism	• Staffed-secured	• Adequate
	• Fire suppression system	• To be determined	• To be determined

Work to be Done:

1. Review record drawings and construction specifications.
2. Perform site specific geotechnical, structural, mechanical, electrical systems inspection and evaluation. Also evaluate adequacy of capacity and redundancy.
3. Identify deficiencies and evaluate improvement options to strengthen the pump station to withstand or allow minor damage at PGA 0.6-0.7 or conform to Building Code.
4. Estimate cost of improvements, engineering and construction, and perform cost benefit analysis. As LMPS is constructed in liquifaction area, the improvement options need to consider the system operation and the construction of redundant facility at a different location. This evaluation is an early completion item and needs to recognize the Central Pump Station upgrading project, as the Lake Merced Pump Station will be a backup facility to serve the Sutro area.
5. Implement improvements.

Facility: CDD Pump Stations

Description: CDD pump stations are necessary to pump water from lower elevation to distribution reservoirs or storage tanks located in higher zones. The following is general information on the city pump stations.

PUMP STATION	YEAR BUILT	# OF PUMPS	PUMP CAPACITY (MGD)
Mt. Davidson	1952	2	0.5
Potrero Heights	1950	2	0.4
Summit	1955 1979	3 1	1.4
McLaren	1967	2	6.4
LaGrande	1956	2	0.2
Bernal Heights	1914 1976	2 (Original) (Modified)	Not in Service

Hazard Event: Worst case seismic event:

San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)

Seismic events following which this facility must remain operable

San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2-0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, 0.0 – 0.1)

Critical Function: Pump water to distribution reservoirs or storage tanks.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Mt. Davidson 0.5 mgd • Potrero Heights 0.4 mgd • Summit 1.4 mgd • McLaren 6.4 mgd • LaGrande 0.2 mgd • Bernal Heights 0.2 mgd	• Adequate	• None
Structural	Withstand PGA 0.6-0.7: • Mt. Davidson	• To be determined	• To be determined

	- Summit	- To be determined	- To be determined
	- McLaren	- To be determined	- To be determined
	- LaGrande	- To be determined	- To be determined
	Withstand PGA 0.4-0.5:		
	- Potrero Heights	- To be determined	- To be determined
	- Bernal Heights	- To be determined	- To be determined
Mechanical / Electrical	- Flexible joint to allow horizontal movement	- To be determined	- To be determined
	- Isolation valves to allow switchover	- To be determined	- To be determined
	- Spare pump to allow replacement	- To be determined	- To be determined
	- Pump Anchor to withstand PGA indicated in "Structural Integrity" section of this table	- To be determined	- To be determined
	- Standby power supply	- To be determined	- To be determined
Security	- Automated Surveillance	- Not staffed	- Adequate
	- Fire suppression system	- To be determined	- To be determined

Work to be Done:

1. Review record drawings and construction specifications.
2. Conduct site specific geotechnical, structural, mechanical and security inspection.
3. Identify deficiencies and improvement options to withstand respective PGAs as indicated above. Also, work is to be considered with CDD Pump Station upgrading project. A report is being finalized by the Department of Public Works.
4. Estimate cost of improvements, engineering and construction.
5. Early completion item.

Facility : CDD Tanks

Description: CDD Tanks are used to supplement the water storage of the water supply system. The water enters the tank via pump stations and tanks can either be constructed with steel or concrete. The followings is general information on the city tanks.

TANK	YEAR BUILT	TYPE	TANK CAPACITY
Mt. Davidson	1953	Concrete	75,000 gal
Lincoln Park	1924	Concrete	75,000 gal
Forest Hill	1944	Concrete	300,000 gal
Potrero Heights	1950	Steel	100,000 gal
LaGrande	1956	Steel	300,000 gal
Forest Hill	1926	Steel	300,000 gal
Forest Knolls	1960	Steel	100,000 gal
McLaren	1966	Steel	8,000,000 gal

Hazard Event: Worst case seismic event:
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Seismic events following which this facility must remain operable
San Andreas Fault (7.9 magnitude, PGA 0.6-0.7)
Hayward Fault (7.1 magnitude, PGA 0.2-0.3)
Calaveras Fault (6.8 magnitude, PGA 0.1-0.2)
Great Valley Fault (6.7 magnitude, 0.0 – 0.1)

Critical Function: Supply potable water and fire protection water to city customers.

Delivery Capability Assessment:

DELIVERY CAPABILITY	REQUIRED	ACTUAL	DEFICIENCY
Capacity	• Mt. Davidson 75,000 gal • Lincoln Park 75,000 gal • Forest Hill 600,000 gal • Potrero Heights 100,000 gal • LaGrande 300,000 gal • Forest Knolls 100,000 gal • McLaren 8,000,000 gal	• Adequate	• None
Structural	Withstand PGA 0.6-0.7: • Mt. Davidson • Lincoln Park • Forest Hill • LaGrande • Forest Knolls • McLaren Withstand PGA 0.4-0.5: • Potrero Heights	• To be determined • To be determined • To be determined • To be determined • To be determined • To be determined • To be determined	• To be determined • To be determined • To be determined • To be determined • To be determined • To be determined • To be determined
Mechanical / Electrical	• Flexible joint to allow horizontal movement • Isolation valves to allow switchover • Tank anchor to withstand PGA indicated above • Standby Power	• To be determined • To be determined • To be determined • To be determined	• To be determined • To be determined • To be determined • To be determined
Security	• Automated surveillance when unstaffed • Fire suppression system	• To be determined • To be determined	• To be determined • To be determined

Work to be Done:

1. Review record drawings and construction specifications.
2. Conduct site specific geotechnical, structural, mechanical and security inspection.
3. Identify deficiencies and improvement options to withstand or allow minor damage under respective PGAs as indicated above.
4. Estimate cost of improvements, engineering and construction.
5. Early completion item.

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT: Technical Memorandum No. 4
Appendix C: Example Scope of Work to Determine Customer Service Demands

PREPARED BY: The Water Reliability Partnership

DATE: July 30, 1999

APPENDIX C

EXAMPLE SCOPE OF WORK TO DETERMINE CUSTOMER SYSTEM DEMANDS

Purpose: Hazard events result in different demands on the SFPUC system for each customer. The purpose of this task is to determine a customer's system demands, based on an analysis of vulnerabilities and needs. Once customer's system demands have been determined, coordination among the various customers of the system is possible. To best determine customer demands, two analyses are required:

A. an initial analysis or series of coordinations, to set a common basis by which each customer can then determine their individual demands, and

B. analysis of individual customer system demands

We present scopes of work for each of these analyses.

A. COORDINATION FOR COMMON BASIS FOR ANALYSIS

Prior to performing individual customer demand analyses, it is of value for the various customers and the SFPUC to coordinate the basis on which each individual customer system analyses will be performed. The purpose of this coordination is to (a) identify which hazards, and the specific parameters of those hazards, to be used for system analysis, (b) identify what customer needs are to be met by each system, in what time frames, and (c) identify what demands each system will make on the SFPUC system, and how to characterize those demands. This coordination most probably will occur interactively during several workshops, during the following tasks:

A-1. *System Coordinator*: Identify an SFPUC or BAWUA staff or consultant to serve as a central focus for information and coordination. To the extent possible, this person or organization should have an understanding of the SFPUC and individual BAWUA systems, a good technical understanding of seismic and other hazards impacts on these systems, and of system reliability analysis.

A-2. *Hazards Characterization*: System Coordinator reviews TM 1 of Phase 2 to identify which hazards each BAWUA system should be analyzed for, and recommends specific parameters of each hazards (e.g., M_W 7.9 San Andreas event). SFPUC and BAWUA confer and agree, or modify hazards and/or their parameters.

A-3. *Demand Characterization*: System coordinator confers with SFPUC and BAWUA staff to preliminarily identify what demands individual systems will be attempting to meet (examples of demands include potable and commercial needs, broken pipes or other system impacts, and firefighting or other emergency response needs). Demands can be determined on any of several bases (e.g., under as-is conditions so that broken pipes and other damage create large demands; under no-damage conditions; under damage-isolated conditions; also, under normal consumption, or under some degree of rationing or reduced demand). System coordinator recommends how demands are to be characterized for various time frames (e.g., immediately after event, Day 3, Day 10, Day 30). SFPUC and BAWUA confer and agree, or modify demands and how they are to be characterized / reported.

A-4. *Analysis Guidance*: System coordinator provides limited guidance on methods and techniques on selected aspects of analyzing individual system performance under the hazards identified under Task A-1 (i.e., System Coordinator serves as a technical resource to BAWUA members, to a limited extent. Limits to be defined in Task A-1).

B. ANALYSIS OF INDIVIDUAL CUSTOMER SYSTEM DEMANDS

Scope of Work: In order to determine the customer's system demands on the SFPUC system, the following analyses are needed.

B-1. *Hazard Analysis*: Review available literature to specify impacts to the customer's system related to the selected hazards. Quantify intensity of characteristic large events for each hazard within the customer system, including at specific significant sites such as storage reservoirs or pump stations.

Product: Maps, tables or other data quantifying the intensity of major hazards within the customer service area and at specific significant sites.

B-2. *Exposure Analysis:* Compile an inventory of significant storage and other water system facilities, for use in the System Analysis task. Also, compile an inventory of the service area residential, commercial, and other types of buildings and elements, for use in the Demand Analysis.

Product: Maps, tables and other data of the system and general service area built environment, for use in the Demand and System Capacity analyses.

B-3. *Demand Analysis:* For each major hazard event, determine water demands due to a) potable and commercial needs, b) broken pipes or other system impacts, c) firefighting or other emergency response needs. Demands determined for various time frames (e.g., immediately after event, Day 3, Day 10, Day 30).

Product: Quantification of water demands within the customer system, and at the connection to the SFPUC system.

B-4. *System Capacity Analysis:* For each major hazard event, determine system capacity response given the existing system condition and resources. System capacity response is the estimated amount of water the system can provide given the occurrence of the hazard event and the response of the system and operators to the major hazard event and resulting demands. It is to be estimated in two aspects: (a) the most likely response, and (b) the 90th percentile response[1]. Factors to be taken into consideration in this analysis include customer system storage, material, equipment and personnel resources, ability to isolate areas of heavy damage, alternative emergency water supplies, and emergency planning.

Product: Descriptions of system performance and response, with most likely and pessimistic estimates of water which the customer system can furnish in response to the demands.

B-5. *Mitigation Analysis:* Based on analyses similar to the System Capacity Analysis, identify cost-effective and feasible mitigation measures which will improve system response and reduce demands on the SFPUC system. Prioritize these mitigation measures by (a) their contribution to System Capacity, or their reduction in Demand, and (b) their cost per thousand gallon contribution to System Capacity, or reduction in Demand.

Product: Descriptions (with backup justification) of mitigation measures; prioritized mitigation measures.

B-6. *Report:* A report summarizing each analysis, with a summary table suitable for use in a compilation of the overall SFPUC system performance.

---

[1] The 90th percentile response is defined as the response resulting in an amount likely to be exceeded with 10% probability given the major hazard event.

SFPUC Facilities Reliability Program
Phase II – Regional System Overview

SUBJECT: Technical Memorandum No. 4
Appendix D: Framework for Communications

PREPARED BY: The Water Reliability Partnership

DATE: July 30, 1999

APPENDIX D
FRAMEWORK FOR COMUNICATIONS

Introduction

This plan provides a recommended framework for developing a communications program that would be implemented during Phase III of the Facilities Reliability Program and further refined during Phase IV implementation. This plan is intended as a general guide and should be expanded in more detail as the results of Phase III technical studies and identification of quick-turnaround projects are determined.

Integration with Other Communication Programs

Communications activities for the Facilities Reliability Program will need to be coordinated with public outreach programs already in place or planned for other major SFPUC projects to maximize efficiencies and shared resources, and to avoid duplication of effort. Of equal importance will be structuring the program with enough breadth and flexibility to allow Bay Area Water Users Association (BAWUA) members to use their own, already established public outreach methods for communicating with customers and interested parties in their service areas. The following projects will likely include some level of communication objectives and activities similar to those that will be necessary for smooth implementation of the Facilities Reliability Program.

- SFPUC CIP Program Management
- SFPUC/BAWUA Water Supply Master Plan
- SFPUC Sunol Valley Water Treatment Plant Expansion
- SFPUC City Distribution Division Reservoir Capital Improvements
- SFPUC Harry Tracy Water Treatment Plant Improvements
- SFPUC Hetch Hetchy Water Supply Chloramine Conversion Project

Most notably, the SFPUC is planning to hire a Program Manager in the next six months to oversee the entire Capital Improvement Program, which will include preparing a 15- to 20-year communications program to manage outreach needs on all major capital improvement projects. Communication activities under the Facilities Reliability Program would need to be consistent with the goals and framework of the Program Management communications plan. To determine this arrangement, it will be important to coordinate closely as the Program Manager's long-term communication program is defined to ensure efficient integration of the Facilities Reliability Program, and consistency in requests for information from and to BAWUA agencies.

Several of the major SFPUC capital improvement projects planned or underway are included on the Facilities Reliability Program's list of critical facilities. The SFPUC's City Distribution Division's (CDD), for example, is planning to start a reservoir capital improvement program in 1999, which may include community relations support and neighborhood-specific outreach near sites of proposed improvements and new facilities. The communication program for the Facilities Reliability Program will need to take this into account to coordinate activities and avoid duplication. The Facilities Reliability Program will also need to integrate efforts with the public outreach activities proposed during implementation of the Sunol Valley Water Treatment Plant expansion and improvements to the Harry Tracy Water Treatment Plant.

General Approach to the Facilities Reliability Communication Program

The general approach to the Facilities Reliability Communication Program will focus on:

- Anticipation of likely public issues
- Results of Phase III technical studies
- Overall program phasing
- Integration with other communication programs.

It will be important to conduct a broad level of educational outreach to the entire program area to help raise awareness and understanding of the critical purpose and need of the Facilities Reliability Program and how project prioritization and financing are determined. Educational efforts will be necessary to help the public understand the magnitude and importance of the entire system and to facilitate understanding of how individual components and facilities play a vital role in the overall system.

The pipelines slated for repair and upgrade in San Francisco, for example, tend to be smaller than the very large transmission pipelines on the Peninsula. The general public, however, may not be aware of this difference in size, and thus may not understand why the costs and construction impacts may differ greatly from area to area. Communicating the potential dire consequences of **not** implementing the projects may also be an effective way of helping people understand the costs and importance of the program. More focused outreach tailored to the needs of specific neighborhoods or areas will be important during the environmental review and implementation of individual projects.

Potential Issues

Below are some of the major public issues and perceptions the SFPUC might consider in shaping specific communication activities for the Facilities Reliability Program. These are based on public response to other recent or ongoing SFPUC activities and projects.

Cost and ratepayer impacts. Educating people about the critical need of the overall program and individual components will be vital to help build support for and lessen opposition to future rate increases and improve understanding of the project costs. As part of this, the SFPUC will need to explain and communicate the rigorous, sound approach used to prioritize projects and determine costs and financing methods. This level of outreach will be extremely important in light of the1998 passage of Proposition H in San Francisco, freezing water and sewer rates at current levels through 2008. Recent media coverage also reflects some concern about rate increases and financing, as noted in the *Chronicle's* June 2, 1999 story on Peninsula officials' opposition to a recent 35 percent wholesale water rate increase and support for Assembly Bill 1398, which would prohibit the subsidy of San Francisco water by suburban customers. The *San*

Francisco Independent's January 26, 1999 article criticizing the SFPUC's reallocation and distribution of bond money for capital improvements also reflects perception issues that should be addressed in the overall communications program.

Stakeholder role in reviewing alternatives and in implementation planning. It will be important to include specific stakeholders (i.e., BAWUA agency representatives) in the development and review of specific projects and major project alternatives as they are identified during the Phase III technical studies and analyses. Likewise, it will be critical to 1) carefully explain to other stakeholders (e.g., key representatives of other interested and affected parties) the site selection process for development, during Phase IV, of any new facilities, and 2) provide a forum for broader public input during the Phase IV process.

Safety/health issues. Safety and health are common issues raised by the public during projects associated with water storage, distribution, and treatment facilities. Communications materials and activities will need to address the importance of improvements under the Facilities Reliability Program in helping to ensure a continued, safe water supply in the event of a major disaster. This message will most likely be addressed in several other ongoing SFPUC outreach programs, including those of the CIP Program Manager and Water Quality Bureau.

Construction and service impacts. Outreach to people potentially directly affected by construction is particularly important to acknowledge possible disruption and address fears or concerns about construction impacts. During Phase IV, efforts will need to clearly identify and explain proposed construction schedules and impacts to people living near or served by particular facilities and seek their input on mitigation measures to address these impacts. Outreach will also be important to keep nearby property owners and occupants well informed and updated throughout the construction process to avoid surprises. In addition, both the long-term benefits and any potential temporary impacts to water service or quality resulting from the facilities improvements should be communicated.

Program Phasing

The communications program would be structured around the major technical milestones in the overall Facilities Reliability Program. Phase III tasks will identify specific projects which in turn help focus the communication efforts for Phase IV. Communication efforts during Phase III might include the start of some level of broad, educational outreach focused on educating the public and BAWUA customer decision makers on the consequences of not increasing the reliability of the SFPUC system. These educational efforts would be continued throughout the program, as well as focused, area-specific outreach associated with the selection of project alternatives. Phase III would also include obtaining input from BAWUA customers regarding the development and analysis of alternatives. Communication efforts during Phase IV project implementation would include both broad educational efforts, as well as outreach during the environmental review, design, and construction of specific projects.

Stakeholders, Target Audiences, and Interested Publics

BAWUA. BAWUA representatives will be integrated into the Phase III process as a primary stakeholder with a vested interest in the process and the resulting improvements. A workshop is recommended as an Early Implementation Activity prior to the start of Phase III, to communicate the overall process, to request data from BAWUA members, and to describe the iterative process of providing preliminary results to SFPUC customers to aid in their own system reliability planning. The BAWUA Board of Directors and the San Francisco Public Utilities Commissioners are also key stakeholders; they will be kept apprised of the Phase III progress.

Other Stakeholders. Below is a representative list of stakeholders and target audiences that may have a strong interest in the implementation phase of the Facilities Reliability Program. The list is based on groups who have actively followed or participated in other local water-related or infrastructure planning projects. During the implementation of the Phase III, additional efforts to identify other key groups in all affected urban and suburban areas will be conducted, drawing on and coordinating with the stakeholder lists and databases already developed for other SFPUC projects.

Representative List of Local, State, and Federal Agencies

SFPUC Commissioners and staff
BAWUA Board members and staff
San Francisco Board of Supervisors and Mayor
County and city elected officials throughout the SFPUC service area outside of San Francisco
County and city public health departments
Regional Water Quality Control Board
San Francisco Bay Conservation and Development Commission
California Department of Fish and Game
California Department of Health Services
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Army Corp of Engineers
U.S. Bureau of Reclamation

Representative List of Environmental Groups

Sierra Club
Natural Resources Defense Council
Alameda Creek Alliance
Communities for a Better Environment
California League of Conservation Voters
Clean Water Action
Save the Bay
Environmental Defense Fund
Tri-City Ecology
California Native Plant Society

Baykeeper

Representative List of Special Interest Groups
League of Women Voters
San Francisco Tomorrow
California Urban Water Agencies
California Water Environment Group
Coalition of San Francisco Neighborhoods
SPUR
Merchants associations (local/ethnic)
Chambers of Commerce
The Utility Reform Network
San Franciscans for Reasonable Reform
Citizens Against Water and Sewer Rate Abuse (San Francisco Prop H proponents)

Representative List of Media
Major daily newspapers and television stations in San Francisco, the East Bay and Peninsula
Local, neighborhood, and alternative language newspapers that serve the areas near specific project sites
Newsletters of special interest organizations
Electronic media – web sites of SFPUC and BAWUA member agencies

Representative List of Property Owners and Occupants
Homes and businesses adjacent to proposed facility sites or traffic routes